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Volume 7, Issue 1

Mobile Radio Technology

The journal of mobile communications technology

577

Frequency synthesizers, p. 10

Paging system coverage

IMCE convention wrap-up

ENTELEC '89 conference review

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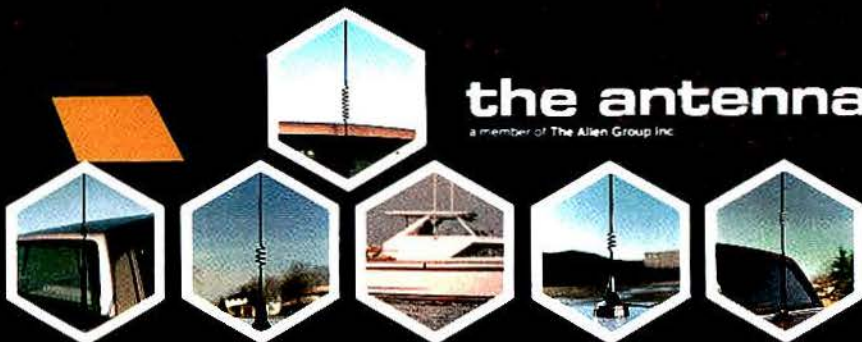
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- C-540 tone (coming later...four frequency, 10 line)
- C-581/M tone (eight frequency)

Wall-mount versions

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- C-512 tone (two frequency)

Custom versions

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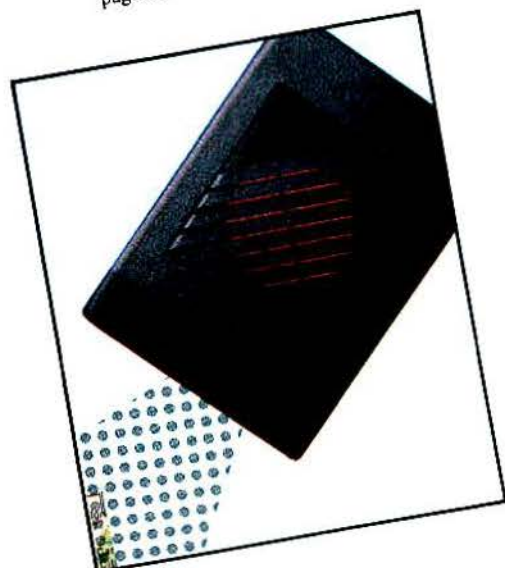
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page 4



page 32



page 48

features

10 Frequency synthesizers: How they work

Harold Kinley, CET, South Carolina Forestry Commission
Part 1—A refresher about digital phase-locked loop (PLL) frequency synthesizers used in high-tech mobiles and portables.

32 Convention speakers see glowing future for mobile communications

Jane Bryant
Technological developments and regulatory actions fuel the growth of land mobile communications. During the International Mobile Communications Expo in Las Vegas, NV, industry sources analyzed the future for markets at home and abroad.

40 ENTELEC '89 conference boasts 30 technical papers

Don Bishop
Technical sessions at the Energy Telecommunications and Electrical Association conference in New Orleans covered system planning, design, implementation and maintenance. Bound copies of technical papers presented are available.

48 Paging coverage vs. frequency

Jim Hathaway and Roy Holmes, Reach Electronics
Pagers have no range, in and of themselves. Paging systems have coverage areas. No matter. Systems equipment buyers still want to know the range of the pager. Here's how to answer "What's the range of my pager?"

On the cover: A Bendix/King 148MHz to 174MHz, 2W transmitter board with voltage-controlled oscillator and frequency synthesizer circuitry represents one of today's high-tech mobiles and portables. See Harold Kinley's article on page 10.

departments

4 Editorial

Interoperability, Nevada style.

6 Letters to the editor

A tip about radio interference.

64 News

Two-way system operators meet to hear technical advice.

75 ACT update

Technicians take certification exam.

76 Regulating technology

Frequency coordination report elicits industry comments.

78 New products

Jack Daniel Company, EWA-Marine and Tauber Electronics are the "Readers' Choice."

81 Literature

82 Feedback

Forest Service land use fees are "unreasonable."

83 People

Promotions at Quintron.

84 Calendar

UTC meets at Orlando, FL.

85 Classified ads

96 Ad index/hotline

Find advertisers quickly.

97 What do you think?

Do you refer to classifieds?

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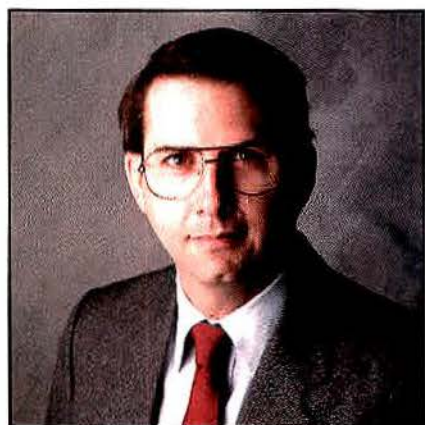
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Interoperability, Nevada style



At the Las Vegas, NV, International Mobile Communications Expo on May 30, we saw a Laughlin Township, NV, constable's vehicle with *nine* antennas! (See photo on this page.)

"There is a radio for each antenna," said Larry Labb, who installed the equipment. Labb is the co-owner and sales manager at The Radio Shop, Walnut, CA. Here's the rundown:

- Six Midland Syn-Tech transceivers, including two VHF wideband units, three UHF units and one VHF lowband unit. The amateur 2-meter band is covered by one of the VHF wideband transceivers.
- One Bendix/King VHF program-mable transceiver.
- One Cobra citizens band transceiver.
- One AM/FM broadcast receiver.
- Each communications antenna is an Antenna Specialists model.

Why so much equipment for one vehicle?

"The radio equipment covers every primary service and mutual aid with every agency," Labb explained. "The vehicle serves as a patrol vehicle and as a disaster services mobile command post." The equipment enables the driver to communicate by radio with emergency services, disaster services, the boat

patrol, the rescue squad, the diving team, civilian communicators and civilian advisers, among others.

Can anyone top that?

* * *

Share your MRT

A reader in Albuquerque, NM, wrote that one of the toughest problems facing him in his job is "sales representatives who are not knowledgeable about equipment they sell."

Suggestion: Share your MRT.

Some articles are for direct use by a technician in performing specific tasks.

Others explain technical aspects of equipment, systems or technologies in more general language.

Let your sales representatives read your MRT. You, and they, may be surprised to find that basic information about communications equipment comes across even to "non-technical" readers.

Aside from the articles, your sales representatives will discover that advertisements and new product information tell them much about products and services they may be offering to your customers.

Careful, though. If this idea catches on with your sales representatives, they may snatch MRT from the mailbox before you have a chance to read it.

—Don Bishop



Nine antennas sprout from a Laughlin Township, NV, constable's vehicle! Each antenna connects with a separate radio. The vehicle was parked in a lot near the International Mobile Communications Expo in Las Vegas, NV.

PRIVACY

Volume 1, No. 5

NEWS
from
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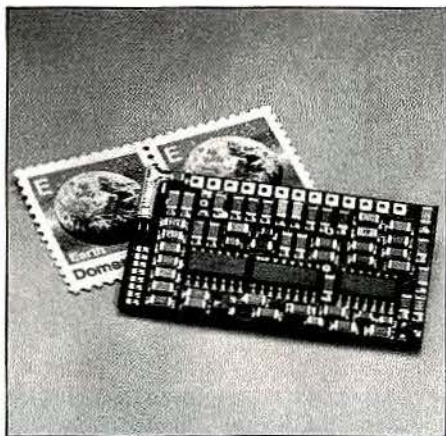
"Perfect...on demonstrations the scramblers sell themselves...real high quality...." (Dealer in Kentucky)

"Working very well...now every police officer wants the extra security...a real nice security addition to our system...." (Police Department in Kansas)

"Nothing but good and great things to say...they work beautifully...we'd love to tell others about them...they're great!" (Police Department in Washington state)

"Excellent field support...Audio quality is better than any other scrambler we have had experience with. We have no complaints." (Dealer in Iowa)

"...at first I thought the scramblers were not working at all because the audio recovery was perfect." (Motorola user in Tennessee)



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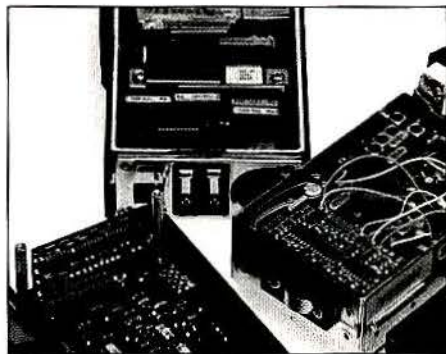
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Meteor-Scatter Radio:

Thank you for printing the January article, "Tracking 64,000 Vehicles With Meteor-Scatter Radio," and thanks to its author, Kathy D. Mickelson.

After reading it, I went home and turned on my old Drake receiver and three-nuvistor converter and began hearing meteor bursts from Kentucky on 49.595MHz. It shows that the old VHF lowband is good spectrum for developing new propagation and modulation modes for land mobile radio.

Ron Johnson
Austin, TX

From Fast Fact Cards:

The toughest problems are finding good, qualified service technicians and getting good service information from manufacturers.

J. Szalajski
SAL Communications
Alstead, NH

As awareness increases of the effect that Freon has on the environment, the need for solvents and cleaners (such as circuit board flux-removing agents) without Freon also is increasing.

Can another reader direct me to a source of circuit board cleaners, coolers and other chemicals used in electronics work, that do not contain Freon?

Klaus Spies
Engineering Technician
8502 N. Oketo Ave.
Niles, IL 60648

The toughest problems are keeping abreast of the many rapid changes in communication equipment and finding space in vehicles for communications equipment. It is difficult to prevent interference between units.

John G. Hudson
Deputy Coordinator
City of Covington, VA

Mobile installation:

I recently encountered a rather time-consuming and aggravating experience involving a mobile radio installation. I thought I would write to you to let know about it so you could pass the information on to your readers.

We had installed a radio in a 1988 Chevrolet Celebrity. The radio operates on a frequency of 153.11MHz.

After the install was complete, the radio was checked for proper operation. A signal was received; it was so strong the squelch would not mute the receiver.

Investigation revealed the signal was so strong that a portable could receive it within 4 feet to 5 feet of the car on any side except behind the trunk. That indicated the car's computer was the probable source. Further checking confirmed that supposition.

Several methods of shielding and grounding that were tried had no effect whatsoever.

I got on the phone and called the radio

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communications technology

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Letters to the editor

manufacturer and the auto manufacturer but no helpful information was to be found. Finally, I called my local Chevy garage and someone there gave me the number of a technical support center. Someone at the support center in turn put me in touch with the computer manufacturer, AC Delco (800-428-0501).

My contact at AC Delco was Don Kuntz. He understood the problem and helped me correct it. He sent a spare computer that operates on a different frequency.

I had to remove the programmable, read-only memory (PROM) from the original computer and install it into the spare, and then install the spare into the car. Those steps took about 20 minutes. The replacement cleared up the interference problem completely.

Mark Eastman

Chevron Information Technology
Amelia, LA

From Fast Fact Cards:

The January 1989 issue was good because it had information useful for public safety agencies. The most interesting article was "Mobile Data Communications For Small Agencies."

Lt. Clarence E. Gavitt
Medical College of Georgia
Public Safety Division
Augusta, GA

Great stuff on fiber optics in the February 1989 issue! Had talked about "...what if there were an antenna-to-radio fiber optic link?" and there it was in print!

John R. Holden
Communications Systems Technician
City of Tucson, AZ

Among the problems faced on the job are:

- finding *competent* qualified help.
- the change manufacturers are implementing in not fixing circuit boards but instead exchanging circuit boards. Troubleshooting to the component level still is possible, but parts are difficult to obtain. They want to sell you a new board instead of a part.

Lee E. Rodby
Tampa, FL



BEWARE OF RUSTLERS ON THE OPEN RANGE

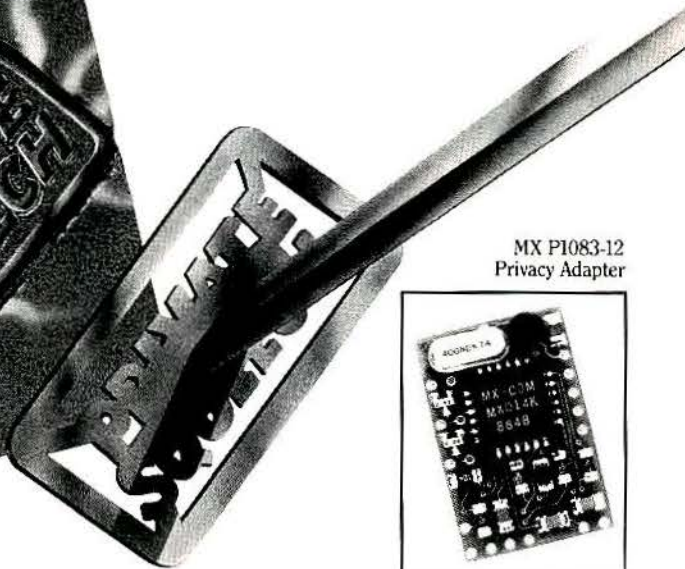


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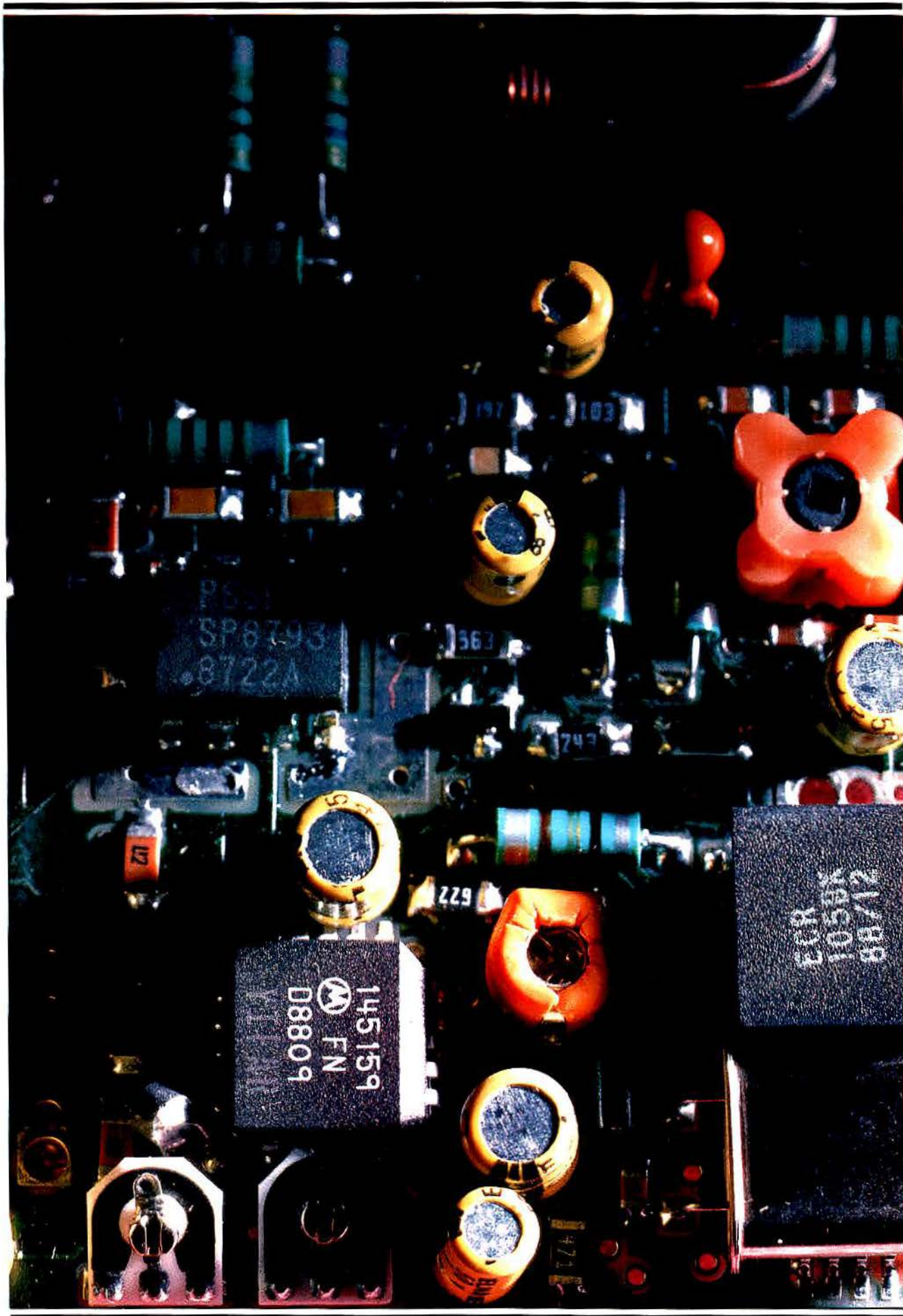
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Circle (9) on Fast Fact Card



Frequency synthesizers: How they work

Part 1—Here is a refresher for those who already have a good working knowledge of digital phase-locked loop (PLL) frequency synthesizers, and a primer for those who are unfamiliar with the circuits.

By Harold Kinley, CET

Digital frequency synthesizers are used widely in land mobile radio equipment. Technicians must understand how they work to troubleshoot and repair them efficiently.

Figure 1 to the right is a digital phase-locked loop (PLL) frequency synthesizer diagram. Color outlines the loop path. The heart of the synthesizer is the voltage-controlled oscillator (VCO). Other system components are there to control the VCO.

Consider the programmable divider to be a channel selector. It determines the VCO's operating frequency. The reference oscillator, its associated reference divider and the phase detector keep the VCO on frequency.

Some explanations will help you to analyze Figure 1:

Phase and frequency detector

Figure 2 on page 12 shows a practical phase and frequency detector. You do not need to understand all of its inner workings because the circuit usually is contained within an integrated circuit (IC) chip.

It is important to understand the relationship among the two input signals F_R and F_{LOOP} and output signals U, D and LD. The loop signal F_{LOOP} is the programmable divider's output. The

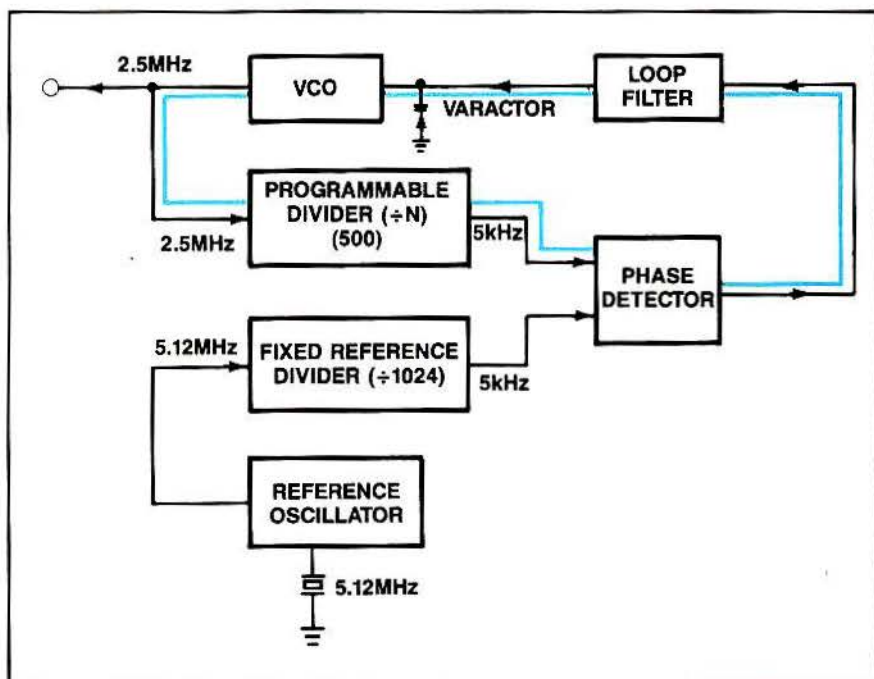


Figure 1. A basic but functional phase-locked loop (PLL) frequency synthesizer. The colored line indicates the loop path.

reference signal F_R is the fixed reference divider's output. Derived from a crystal-controlled oscillator, the reference signal frequency is highly stable.

The loop signal's frequency and phase are compared to the reference signal. If the two input signals are equal in frequency and in phase, both U (UP) and D (DOWN) outputs will be in the logic 1 or high state. The logic states of the U and D outputs change if the two input signals differ in frequency or phase.

Figure 3's timing diagram (page 14) illustrates how the U and D logic states

are affected when the input signals have equal frequency but not in phase. The input signals are compared at the negative transitions. At (A) the two input signals are in phase; both U and D remain in the high state.

At (B) the loop signal leads the reference signal. The U output remains high, but the D output goes low on the reference signal's negative transitions and returns to a high state on the loop signal's negative transitions. Thus, the phase difference produces negative pulses on the D output. The duration of the negative pulse is determined by the

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. His book is *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*. Prentice-Hall, 1985.

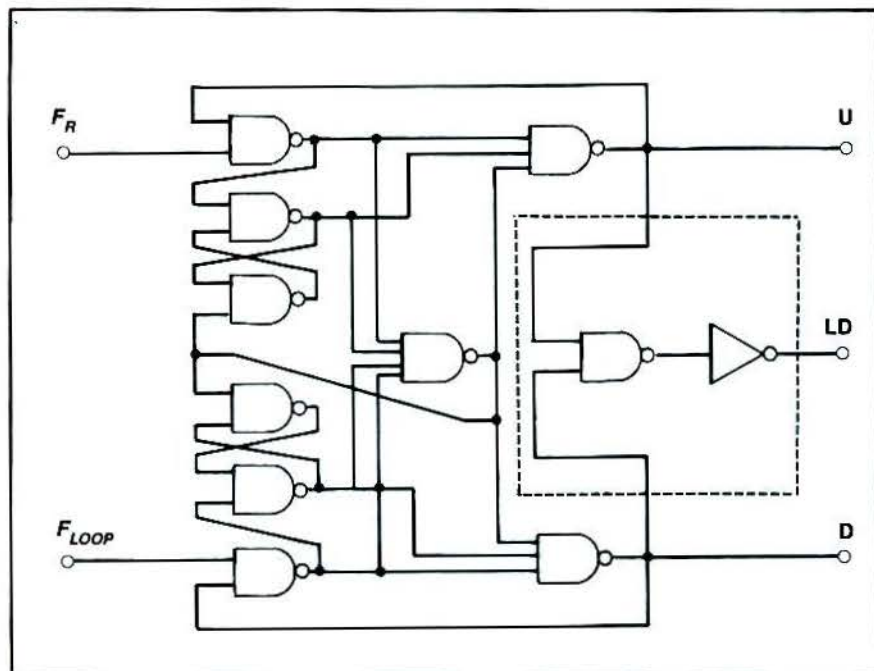


Figure 2. This array of nand gates forms a practical phase/frequency detector. The nand gate and inverter within the dashed line is the lock detector. Bars over the output symbols indicate that the outputs are active low.

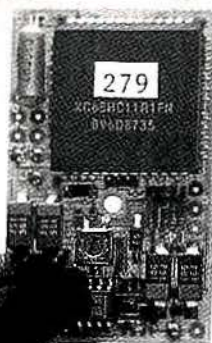
phase difference between the input signals.

At C, the loop signal *lags* the reference signal. The D input remains high but the U output goes low on the negative transitions of the reference signal and back high on the negative transitions of the loop signal. Thus, the phase difference produces negative pulses on the U output. The duration of the negative pulses is determined by the phase difference between the input signals.

Figure 4's timing diagram (page 16) illustrates how the U and D outputs are affected when the two input signals differ in frequency. The loop frequency steadily increases during the interval from T0 to T34; the reference frequency remains constant. From T0 to T19, the loop frequency is lower than the reference frequency. During this interval, the D output is constantly high and the U output pulses between high and low states.

From T19 to T34, the loop frequency

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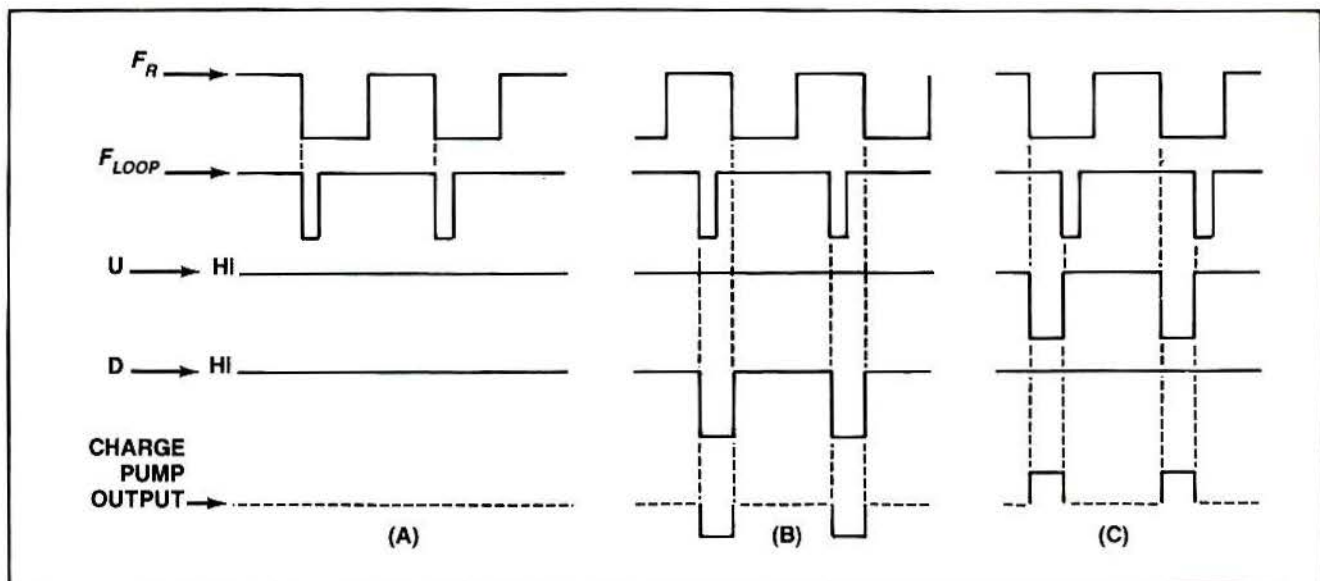


Figure 3. This timing diagram shows how the phase relationship of the reference and loop pulses affects the states of the U and D outputs and the charge pump output. The comparison is made on the negative transitions.

At (A), the loop and reference pulses are in phase. The U and D outputs are high, and the charge pump output is in the open state.

At (B), the loop pulse leads the reference pulse. The U output

remains high. A negative pulse appears on the D output. The pulse width is determined by the phase difference between the loop and reference pulses. The charge pump output is low, as long as the D output is low.

At (C), the loop pulse lags the reference pulse. The D output remains high. A negative pulse appears on the U output. The pulse width is determined by the phase difference between the loop and reference pulses. The charge pump output is high, as long as the U output is low.

is higher than the reference frequency. During this interval, the U output is constantly high and the D output pulses between high and low states.

Lock detector

Associated with the phase and frequency detector is the *lock detector*. Lock detector circuitry is shown within the dashed line in Figure 2. When the loop is phase-locked, lock detector output is a steady high. When U and D are in the high state, lock detector output is in the high state. When either U or D is low, lock detector output is low.

Lock-detect output controls a transmit-inhibit circuit that prevents the transmitter from producing an output signal when the loop is not locked. This safeguard prevents off-frequency operation and possible harmful interference to other radio services.

Charge pumps

Figure 5 on page 18 shows a typical charge pump circuit, along with the phase and frequency detector. The charge pump consists of field-effect transistors (FET) Q1 and Q2, along with the inverter that precedes Q2. Q1, a P-

channel FET, conducts when its gate is negative with respect to the source. Q2, an N-channel FET, conducts when its gate is positive with respect to the source.

Charge pump output controls the VCO control line charge or voltage. Charge pump output may be in one of three states:

- Q1 conducting and Q2 off.
- Q2 conducting and Q1 off.
- both Q1 and Q2 off.

Q1 and Q2 never conduct simultaneously.

The loop filter between the VCO steering line and the charge pump contains an integrating capacitor that holds charge placed on the line via the charge pump. When the loop signal lags the reference signal (or is lower in frequency), phase detector output at D remains high and U output pulsates between high and low states. When U is low, Q1 conducts, increasing the control line's positive charge and thereby increasing VCO frequency.

When the loop signal leads the reference signal (or is higher in frequency), phase detector U output remains high and D output pulsates between high

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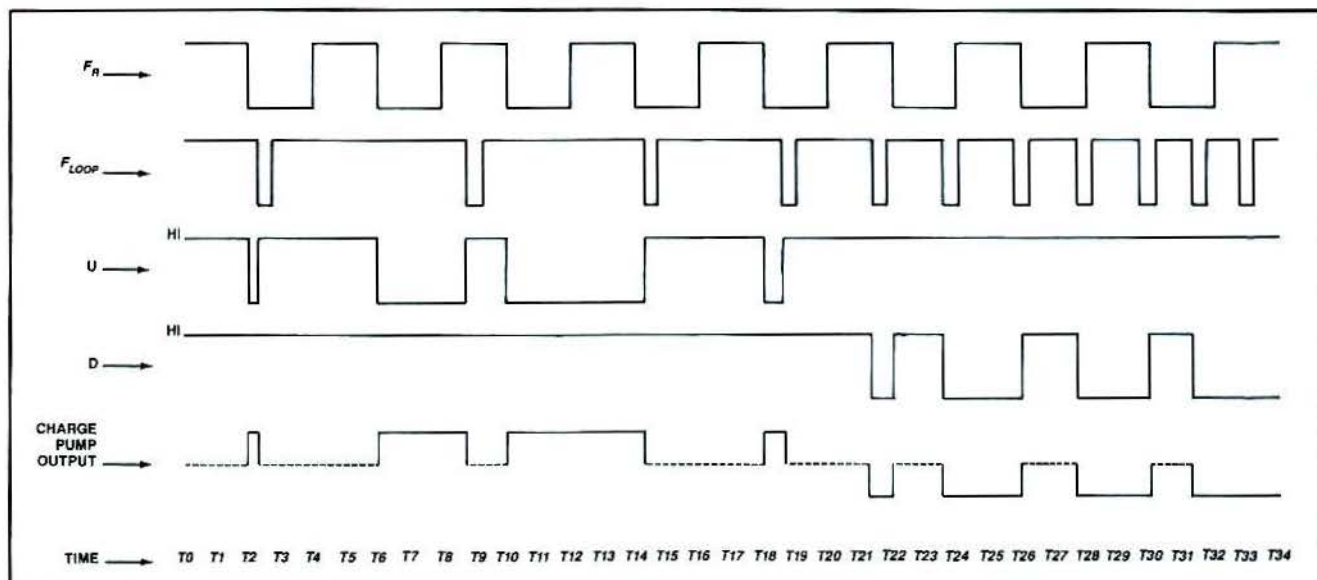


Figure 4. This timing diagram shows how the outputs of the phase/frequency detector are affected by frequency differences on the inputs. From time T_0 to time T_{34} , the frequency of the loop pulses steadily increases. From T_0 to T_{19} , the loop frequency is lower than the reference frequency. The U output pulsates between high and low states as the D output remains high.

frequency. The D output pulsates between high and low states as the U output remains high. When the loop frequency is lower than the reference frequency, the charge pump output produces positive pulses. When the loop frequency is higher than the reference frequency, the charge pump produces negative-going pulses.

From T_{19} to T_{34} the loop frequency is higher than the reference

and low states. When D is low, Q_2 conducts, decreasing the positive charge on the control line and thereby decreasing VCO frequency.

When the loop is phase-locked, both phase detector outputs U and D are high, keeping Q_1 and Q_2 turned off. With both Q_1 and Q_2 off, the charge pump is off (high-impedance state), allowing the control line to "float." Control line charge is unaffected.

Figure 4's timing diagram shows how the input signals' timing affects the charge pump's state. The dashed line represents the high impedance state that exists when neither Q_1 or Q_2 conducts. High pulses represent intervals during which Q_1 conducts; low pulses represent intervals during which Q_2 conducts.

The diagram reveals that when the loop frequency is lower than the reference frequency (T_0 to T_{19}), Q_1 conducts in pulses—the conduction interval depends upon the phase difference between the loop and reference signals.

Conversely, when the loop frequency is higher than the reference frequency (T_{19} to T_{34}), Q_2 conducts in pulses; the conduction time is dependent upon the phase difference between the loop signal and the reference signal.

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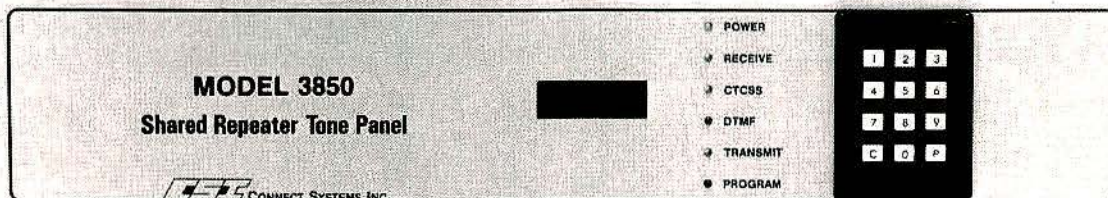


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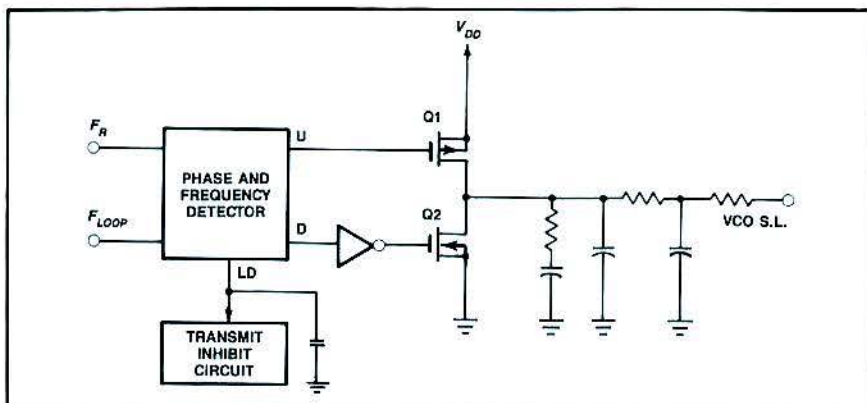


Figure 5. This simplified diagram shows how the phase and frequency detector, charge pump, transmit inhibit circuit and loop filter are interconnected. See text.

Figure 5 also shows how the lock-detect output controls a transmit-inhibit circuit. When the loop is phase-locked, lock detector output is a steady high. The integrating capacitor at the lock-detect output is charged to this high level.

Minor phase differences between the reference and loop signals cause occasional negative-going spikes to appear

on the lock-detect output. The occasional spikes are not enough to reduce the charge on the integrating capacitor to a voltage level low enough to activate the transmit-inhibit circuit.

But large phase differences (frequency differences) cause negative-going pulses on the lock-detect output to last longer and to occur more frequently, reducing the integrating capacitor's

charge to a voltage level low enough to activate the transmit-inhibit circuit.

Notice that the *loop filter* in Figure 5 is the R-C network between the charge pump and VCO steering line. The loop filter's purpose is to remove any pulsations from the error voltage so the control voltage applied to the voltage steering line is smooth dc.

The loop's response to frequency changes is governed to a large degree by the loop filter design. If the loop filter bandwidth is wide, the loop has a fast response to frequency changes but the wide bandwidth reduces VCO signal purity. On the other hand, a narrow bandpass improves VCO signal purity and increases the time the loop needs to respond to frequency changes.

A compromise must be made between loop response time and VCO signal purity.

The programmable divider may be considered to be a channel selector because it is the "divide number" or "count" programmed into the divider that determines the VCO operating fre-

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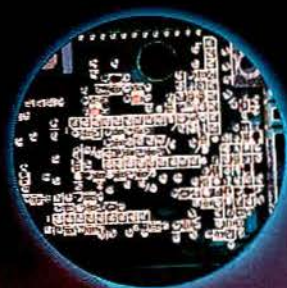
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quency. Programmable counters can be up-counters or down-counters.

When up-counters are used as programmable dividers (counters), the counter is preset or programmed to count to a certain number N . When it reaches this count, it produces an output pulse, resets and counts anew.

A down-counter is preset or programmed to a certain number N and

counts down from that number to zero. When it reaches zero, it resets and counts anew. Down-counters commonly are used in programmable dividers.

A block diagram of a programmable divider is shown below in Figure 6. The "weight" of each of the nine program lines, P0 to P8, is shown. Programming this divider is done via the "pure" binary form. With nine program

lines, the maximum divide number N is $29 - 1 = 511$.

To program the divider, a binary 1 (high) or binary low (0) is placed on the individual program lines. To determine the divide number N , the program lines' individual weights at the binary 1 level are added.

For example, if P8, P5 and P0 are at binary 1 level (all others at binary 0), the number programmed into the divider N is $256 + 32 + 1 = 289$. Thus, 289 pulses on the input produce one pulse on the output.

Programmable dividers or counters

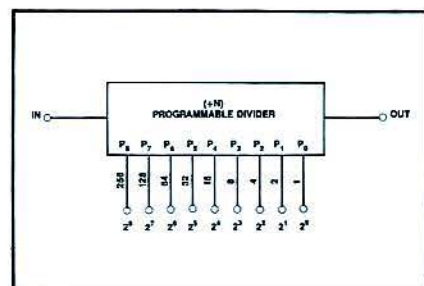


Figure 6. This block diagram represents a programmable divider. The logic levels on the program lines (P0 to P8) determine the divide number N that is programmed into the divider. Various weights of program lines are shown. Output signal frequency equals the input frequency/ N .

Receive only	Freq. Ranges (MHz)	N.F. (dB)	Gain (dB)	Comp. (dBm)	Device Type	Price
P30VD, P35VD, P40VD, P45VD	30-35, 35-40, 40-45, 45-50	<1.3	15	0	DGFET	\$ 44.95
P30VDG, P35VDG, P40VDG, P45VDG	30-35, 35-40, 40-45, 45-50	<0.5	26	+12	GaAsFET	\$109.95
P150VD, P160VD, P170VD	150-160, 160-170, 170-180	<1.5	15	0	DGFET	\$ 44.95
P150VDA, P160VDA, P170VDA	150-160, 160-170, 170-180	<1.1	15	0	DGFET	\$ 56.95
P150VDG, P160VDG, P170VDG	150-160, 160-170, 170-180	<0.5	24	+12	GaAsFET	\$109.95
P450VD, P460VD	450-460, 460-470	<1.8	15	-20	Bipolar	\$ 49.95
P450VDA, P460VDA	450-460, 460-470	<1.2	16	-20	Bipolar	\$ 74.95
P450VDG, P460VDG	450-460, 460-470	<0.5	16	+12	GaAsFET	\$109.95
P800VDG, P830VDG, P860VDG	800-830, 830-860, 860-890	<0.6	19	+12	GaAsFET	\$119.95
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SP30VDG, SP35VDG, SP40VDG, SP45VDG	30-35, 35-40, 40-45, 45-50	<0.55	26	+12	GaAsFET	\$139.95
SP150VD, SP160VD, SP170VD	150-160, 160-170, 170-180	<1.6	15	0	DGFET	\$ 74.95
SP150VDA, SP160VDA, SP170VDA	150-160, 160-170, 170-180	<1.2	15	0	DGFET	\$ 86.95
SP150VDG, SP160VDG, SP170VDG	150-160, 160-170, 170-180	<0.55	24	+12	GaAsFET	\$139.95
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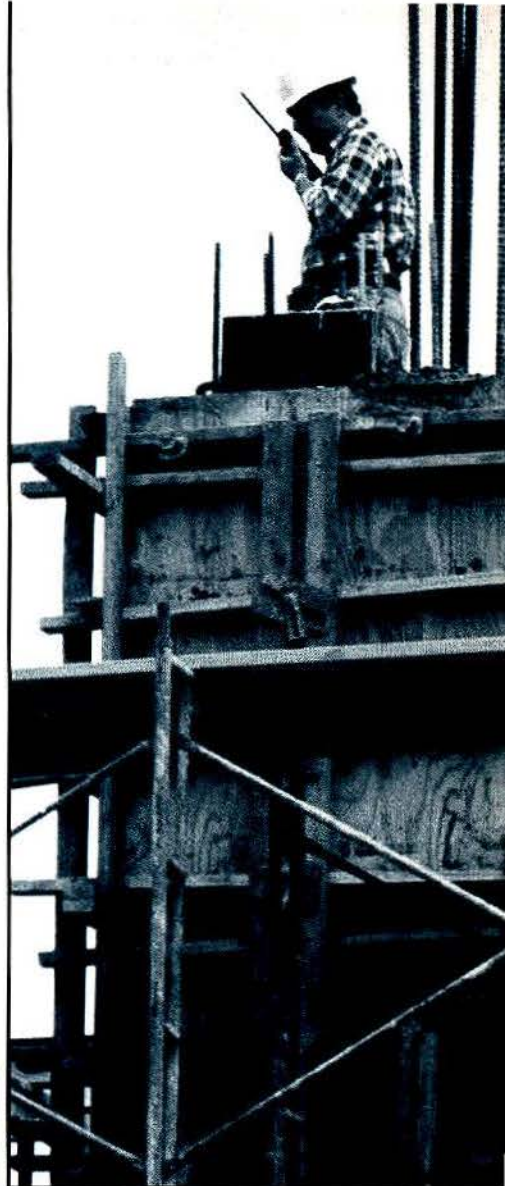
can be programmed by codes other than "pure" binary. For example, the binary-coded decimal (BCD) format may be used. Code converters sometimes are used between the program lines and the programmable divider to convert from one code to another.

An important fact to remember about programmable dividers is that N number of input pulses are required to produce one output pulse.

Voltage-controlled oscillator

Figure 7 on page 22 shows a simple voltage-controlled oscillator (VCO). The varactor diode's capacitance is part of the tuned circuit. The varactor's cathode connects to the steering line. The steering line's positive control voltage reverse-biases the varactor. A reverse-biased varactor acts as a small capacitance. The higher the reverse bias, the smaller the capacitance.

As the steering line's positive control voltage increases, the varactor's reverse bias increases, causing capacitance to



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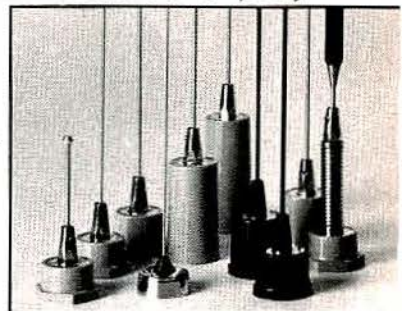
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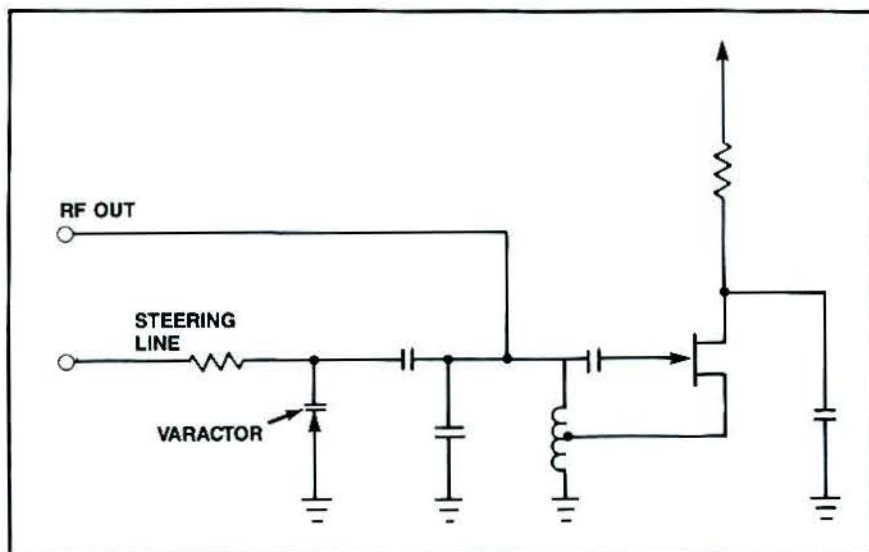


Figure 7. The frequency of this voltage-controlled oscillator (VCO) is controlled by the dc voltage applied to the steering line. An increase in dc steering line voltage increases the VCO frequency. A voltage decrease similarly decreases the VCO frequency.

decrease and increasing the VCO operating frequency. Conversely, when the steering line's positive control voltage decreases, the varactor's reverse

bias decreases, causing capacitance to increase and decreasing the VCO's operating frequency. This relationship explains how the phase and frequency

detector controls the VCO operating frequency.

Basic loop analysis

This discussion refers to the simple PLL circuit shown in Figure 1. The reference frequency at the phase detector reference input is 5kHz. The phase detector and charge pump (not shown) produce a control signal that causes the VCO to operate at $5 \times N$ kHz. In this example, the programmable divider is programmed for $N = 500$, so the VCO frequency must be: $5 \times 500 = 2,500$ kHz, or 2.5 MHz.

The resolution of a PLL frequency synthesizer is equal to the minimum change in N multiplied by the reference frequency. In the PLL circuit of Figure 1, the minimum amount that N can be changed is 1, and the reference frequency is 5 kHz. Thus, the resolution of this PLL synthesizer is 1×5 kHz = 5 kHz.

The simple PLL synthesizer of Figure 1 cannot generate very high frequencies. The operating frequency range is limited

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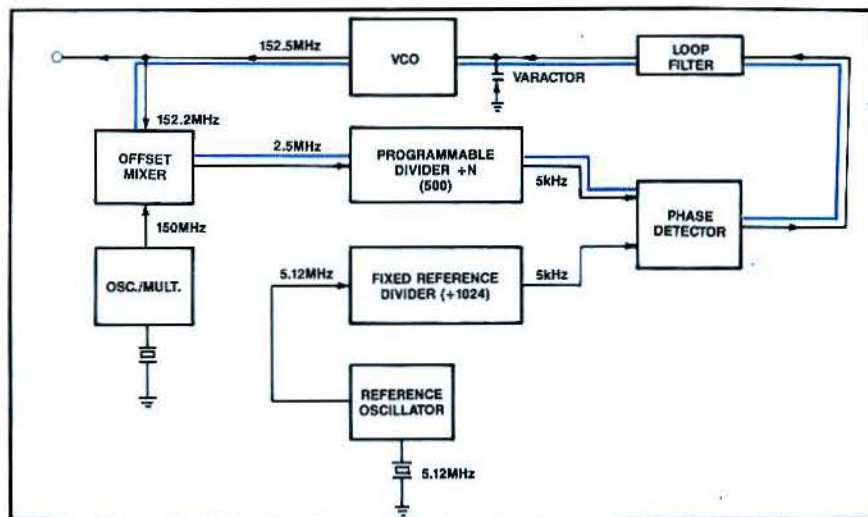


Figure 8. An offset mixer in the loop path (colored line) allows a low-speed divider to control a VCO frequency that is far beyond the programmable divider's normal operating range.

severely by the programmable divider's speed. Several ways may be used to achieve higher frequencies with digital PLL frequency synthesizers:

Figure 8 above shows how an off-

set mixer can be used to increase the operating frequency range of the simple PLL synthesizer shown in Figure 1. The offset mixer is placed into the loop path between the VCO and the program-

mable divider input. The VHF VCO frequency (152.5MHz) is mixed with a 150MHz signal from the oscillator-multiplier circuit to produce a difference frequency of 2.5MHz. The 2.5MHz difference frequency then is fed to the programmable divider's input.

Any change in VCO frequency produces an equal change in the mixer output frequency, and in the same direction. Thus, a relatively low-speed, programmable divider can control a VHF VCO's frequency. Figure 8's synthesizer frequency is the same as that of the Figure 1 synthesizer: 5kHz.

Using offset mixers to increase the PLL synthesizer operating frequency range may not always be practical. More tuned circuits are required and an additional crystal oscillator is needed. Both increase the manufacturing cost.

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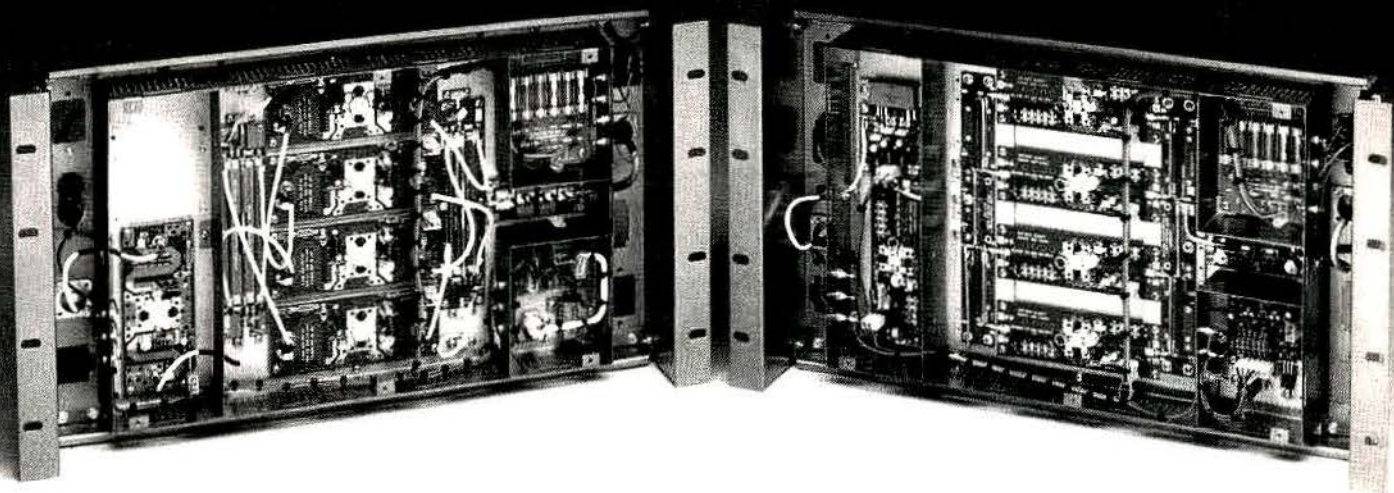
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divider can handle. Figure 9 on page 28 shows such an arrangement.

The fixed prescaler divides the VCO signal by 60 before it is fed to the programmable divider's input. In the Figure 8 example, the 150MHz VCO signal is divided down to 2.5MHz and then fed to the programmable divider.

Figure 9's PLL synthesizer resolution equals the prescaler divide ratio

multiplied by the reference frequency: $60 \times 5\text{kHz} = 300\text{kHz}$. Thus, the minimum amount of frequency change possible is 300kHz. This arrangement would work fine in a radio service with 300kHz between channel assignments, but it would not work in a service with frequency spacing less than 300kHz.

To maintain the same 5kHz resolution, the reference frequency also would

have to be divided by 60. Such a low reference frequency would impose severe filtering requirements on the loop filter, slowing its response and increasing acquisition time.

Dual modulus prescaler

A means of overcoming the limitations imposed by the fixed (single modulus) prescaler is offered by the dual modulus prescaler. Emitter-coupled logic (ECL) dual modulus prescalers can operate in the gigahertz range. ECL prescalers are remarkably fast but not highly programmable. But by combining them with complementary metal oxide semiconductor (CMOS) or TTL programmable counters, the result is an extremely fast and highly programmable combination.

A typical dual modulus programmable divider arrangement is shown in Figure 10 on page 30. It includes two programmable counters, A and B, and a dual modulus prescaler. (The same arrangement is used in the GE Phoenix-SX mobile radio.) The count programmed into the A counter determines how many times the prescaler divides by 65. After $65 \times A$ pulses on the prescaler input (A), the A counter changes states. The A counter output changes the modulus of the prescaler from 65 to 64. At this point the A counter becomes inactive and the count remaining in the B counter is $B - A$.

After $64(B - A)$ more pulses on the prescaler input (A), B counter output (D) changes states. The B counter output, in addition to serving as the main output, presets both the A and B counters. When the A counter is preset, the prescaler modulus is switched back to the $\div 65$ mode and the count cycle repeats.

The overall divide ratio N of the programmable counter in Figure 10 is derived as follows:

$$\begin{aligned} N &= 65A + 64(B - A) \\ &= 65A + 64B - 64A \\ &= A + 64B \end{aligned} \quad (1)$$

The overall divide ratio N also can be determined by the formula:

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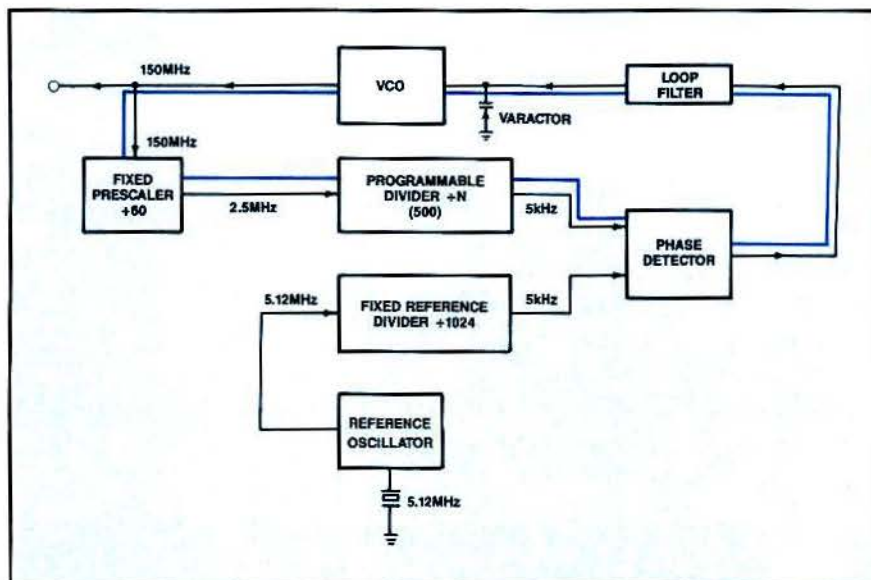


Figure 9. A prescaler inserted into the loop path (colored line) allows a low-speed divider to control a high VCO frequency, but resolution is sacrificed. Resolution equal the prescaler ratio multiplied by the reference frequency—300kHz in this case.

$$N = F_V / F_R \quad (2) \quad \text{and } F_R \text{ is the reference frequency in kHz.}$$

where F_V is the VCO frequency in kHz. The divide ratio for the B counter can

be determined by:

$$B = \text{QUOTIENT}(N/64) \quad (3)$$

The divide ratio for the A counter can be determined by:

$$A = \text{REMAINDER}(N/64) \quad (4)$$

Example: Find the required divide ratios for the A and B counters for a VCO frequency of 159,270kHz, assuming a reference frequency of 5kHz.

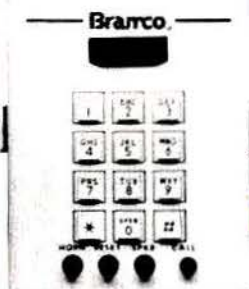
Solution:

$$N = 159,270 / 5 = 31,854; \text{ then:}$$

$$\begin{array}{r} 497 = B \\ 64 \overline{) 31854} \\ \underline{256} \\ 625 \\ \underline{576} \\ 494 \\ \underline{448} \\ 46 = A \end{array}$$

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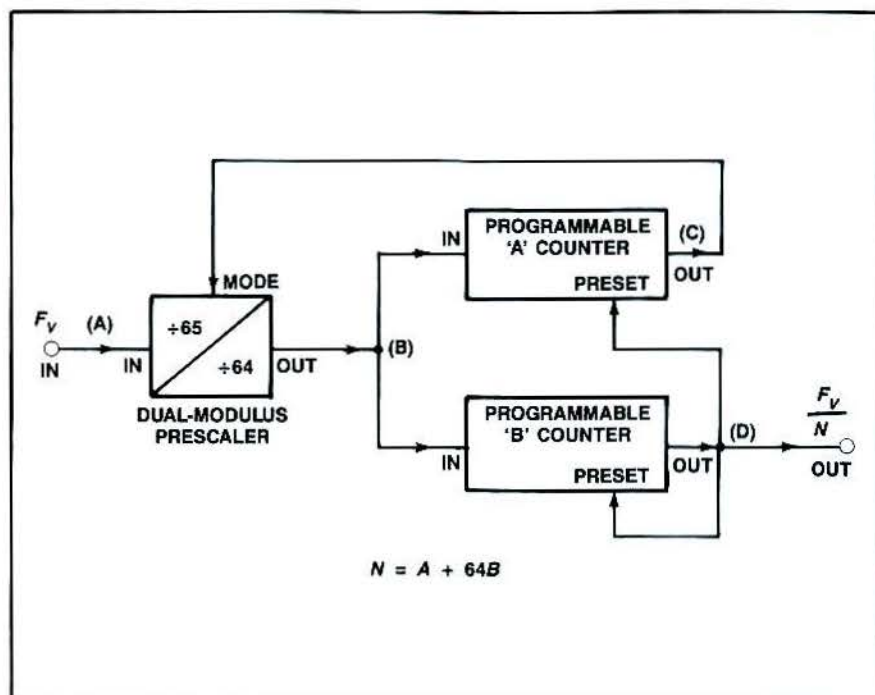


Figure 10. This dual-modulus prescaler combined with low-speed programmable counters allows high-frequency operation without any loss of resolution. This arrangement is used in many dual-modulus synthesizers.

The resolution of a dual-modulus prescaler can be determined by the formula:

$$\text{Resolution} = F_R(U - L) \quad (5)$$

where F_R is the reference frequency, U is the upper modulus and L is the lower modulus.

In the programmable divider discussed above, the resolution (assuming a 5kHz reference frequency) is:

$$5(65 - 64) = 5(1) = 5\text{kHz}$$

This result shows why the upper and lower moduli usually differ by 1: to provide a resolution equal to the reference frequency.

Next month: a practical example showing how to troubleshoot a frequency synthesizer. References will appear at the end of next month's installment.



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Convention speakers see glowing future for mobile communications

Technological developments and regulatory actions fuel the growth of land mobile communications. Industry sources analyze the market's future at home and abroad at the IMCE show in Las Vegas, NV.

By Jane Bryant
Staff Editor

Discussions of the future of mobile communications both domestically and abroad saturated sessions at the International Mobile Communications Expo (IMCE) March 29-31 in Las Vegas, NV.

On the international front, guest speakers from Australia, the Commission of the European Communities and Nippon Telegraph and Telephone outlined mobile's growth in their respective domain.

In the mid-1990s, cellular, trunked, private mobile, paging, mobile satellite and universal portable technologies will contribute to a nationwide personal portable communications system in Australia, according to John Burton, Telecom Australia's director of the strategic planning unit in corporate strategy development.

Burton described communications growth in Australia as extensive. For example, the Australian cellular system adds more than 6,000 subscribers each month. The AMPS cellular system is filling so rapidly, that the country will have to implement a digital cellular system to support subscribers. He predicted a digital cellular system will be on-line by 1992.

"New chip technology has brought mobile communications products within reach and price," commented Prof. Tjakko M. Schuringa, director of telecommunications for the Commission of the European Communities. "Mobile communications could be a real boon."



Ralph Haller: 'The FCC is looking at the de-licensing of end-users.'

According to Schuringa, the objective of the European commission "is to develop conditions for the market to provide European users with a greater choice of modern and cost-effective telecommunications services."

European commission objective

Today in Europe, each country has different mobile telecommunications systems, and there is no cross-border service, he stressed. The European commission has been asked to:

- introduce community-wide approval regime.
- liberalize procurement.
- define social policy.
- define satellite communications policy.

- separate regulations and operations.

Goals of the group are to introduce by 1990 a Europe-wide paging system that incorporates message storage, small pocket devices and visual message display. The group also is eyeing the two-way satellite service for data communications.

It is estimated that 4-million cars cross European borders every year and that 40% of the total could represent cellular mobile users, Schuringa emphasized. The Pan-European Cellular Digital Mobile Telecommunications service starts in Europe in 1991, he stressed, and 15 countries already have signed on for the system. "These services would not eliminate other mobiles services, as they are needed too," he cautioned.

Radiopaging in Japan

Radiopaging is the largest segment of land mobile in use by Japan, according to Minoru Kuramoto, director of systems development of the mobile communications division of Nippon Telegraph and Telephone. Pagers on the system can display both Japanese and Chinese characters, he said. There are 2.8 million radiopaging users in Japan and 230,000 users of other land mobile radio, he said. Cellular telephone serves 85% of the cities and covers 60% of the main routes. Coverage is expected to grow.

The future for U.S. mobile communications depends upon legislative actions on a variety of issues including trunking standards, satellite licensing

and compliance programs for channel loading.

"Land mobile and microwave have attracted interest from investors," commented Ralph Haller, chief of the FCC's Private Radio Bureau. Haller forewarned that due to budget constraints, the FCC may shut down completely for three days in the summer. He emphasized the effects of drastic budget cuts: "We lost 15% of our staff in the Gettysburg, PA, licensing office last year, and there is a hiring freeze."

FCC forecast

Haller forecast commission actions for this year:

- finalize service rules for the 220MHz to 222MHz band that was



The FCC's Ed Jacobs says that the commission is investigating whether public safety agencies are constructing and loading their systems on a timely basis.

reallocated from amateur radio to land mobile radio.

- reply to the American SMR Network Association's request for short spacing of specialized mobile radio (SMR) systems.

- increase power limits on certain paging channels in the 150MHz band.

- de-license SMR end-users.

- reach agreement with Canada on 900MHz licensing in border areas.

- re-examine the restriction against wireline companies from owning SMR systems.

- complete a review of frequency coordination policies.

On the much-debated frequency coordination issue, Haller said the FCC may allow multiple coordinators in each area or may re-instate the field study alternative. A decision is expected this year.

Haller encouraged the sharing of mobile services. He said the industry should take advantage of private carrier



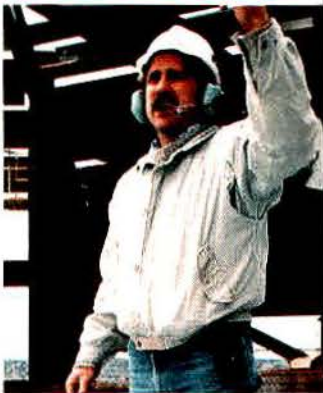

licensing and systems. Private carriers share frequencies; common carriers have exclusive assignments.

An issue the commission still needs to tackle, he said, is how to handle trunking. He exhorted industry members to be vocal with their concerns and suggestions for these and others issues.

Ed Jacobs, deputy chief in the land

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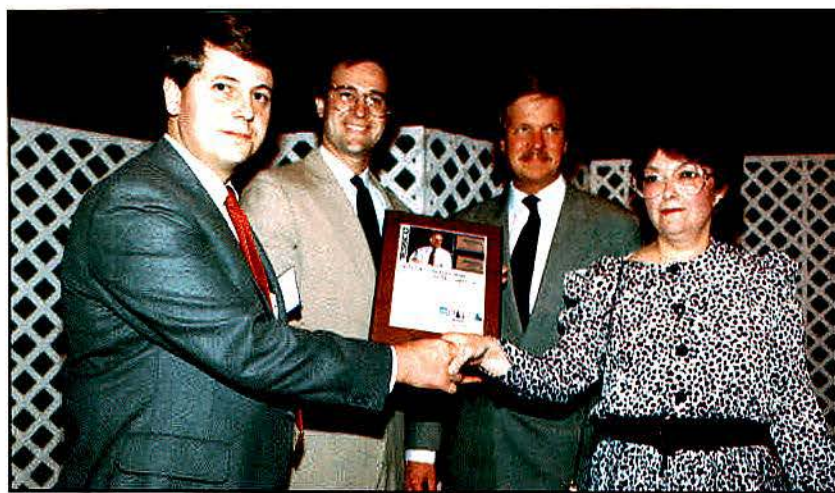
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Tessco wins *MRT's* 'Ad of the Year Award.' From left, Tessco marketing manager Kevin Knight, marketing coordinator Brad Kaplon and president Robert B. Barnhill Jr. receive the award from *MRT* associate publisher and national sales manager Mercy Contreras.

1988 Ad of the Year

Tessco, Cockeysville, MD, won *Mobile Radio Technology's* first "Ad of the Year Award" for its "At Tessco, the Buck Stops With Me...and I Care" full-page advertisement. Tessco was selected from a field of 12 by a panel of marketing and communications specialists. The finalists ads all were "Ad of the Month Award" winners in 1988 and selected by using *Business Marketing* magazine's "Copychasers Criteria."

Kevin Knight, marketing manager; Brad Kaplon, marketing coordinator; and Bob Barnhill, president; accepted the award on Tessco's behalf at *MRT's* hospitality suite March 29 at the International Mobile Communications Expo in Las Vegas, NV.

The "Ad of the Month Award" winners satisfied "Copychasers Criteria" requirements that stipulate the best advertisement:

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- emphasizes the service, not the source.
- reflects the company's character.

Finalists included: Solid State Communications, Hayward, CA; Nett-Worrk Group, Calgary, Alberta; Celwave, Marlboro, NJ; RF Gain, Rockville Center, NY; Coded Communications, Carlsbad, CA; GE Mobile Communications, Lynchburg, VA; ICOM America, Bellevue, WA; Magnavox Advanced Products & Services, Torrance, CA; Midland LMR, Kansas City, MO; Shure Brothers, Evanston, IL; and Yaesu, Cerritos, CA.



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mobile and microwave division of the Private Radio Bureau, addressed the public safety compliance program. He said the FCC is conducting investigations on whether public safety agencies use their frequencies properly.

"Under completion of the investigation, those public safety systems that are not constructed or fully loaded will have their channels recovered," he said. "The

recovered channels are returned to the pool for re-issuance." He added that system licensees can seek license extensions.

Terry Fishel of the land mobile branch of the Private Radio Bureau said that as a consequence of budget cuts, phones at the branch's licensing office in Gettysburg will be answered only between 8 a.m. and 4:30 p.m.

Gerald Vaughan, deputy chief of operations in the Common Carrier Bureau, addressed satellite, paging and cellular actions. Vaughan said a mobile satellite service (MSS) allocation would be decided by late summer or early fall. By the end of 1990, the commission wants to have all cellular construction permits issued, he said.

He also said that in the next 30 days (in April) there should be a public notice on nationwide paging.

Fielding questions from the audience, FCC staffers encountered more queries on frequency coordination. When

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Gerald Vaughan, deputy chief of operations of the FCC Common Carrier Bureau, says the FCC wants to finish issuing cellular construction permits by the end of 1990.

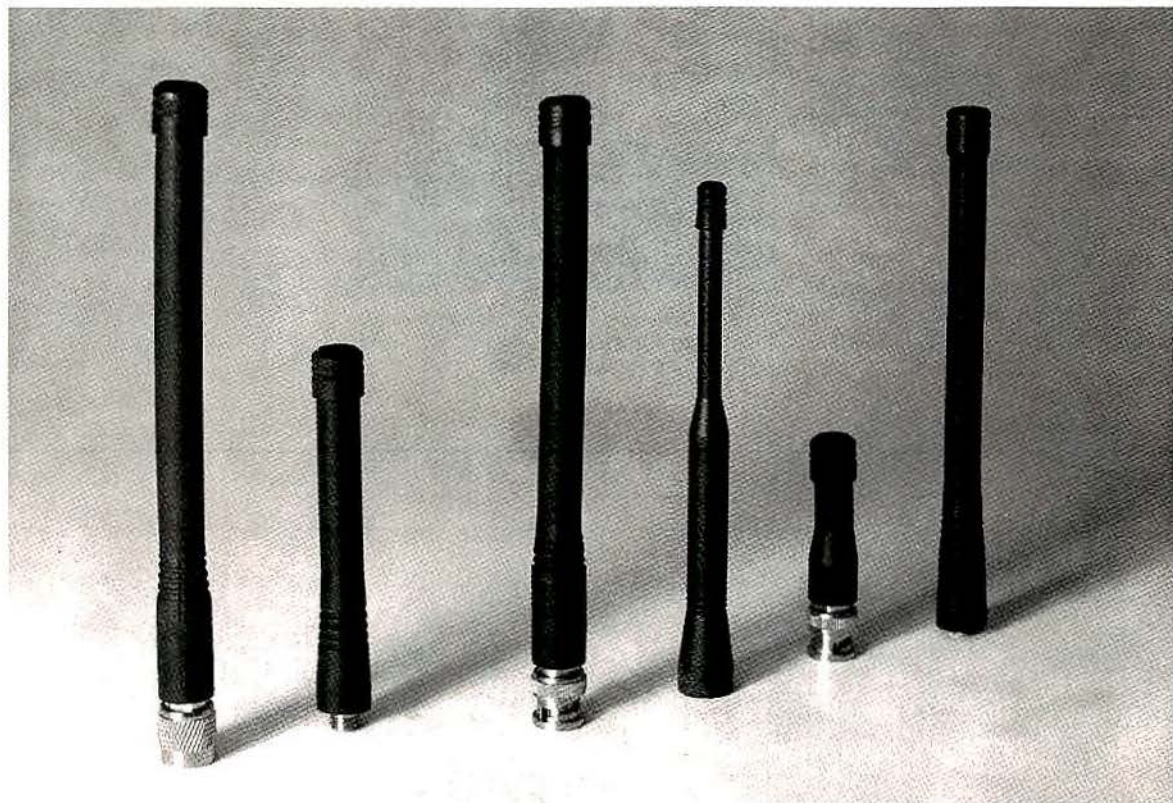
asked, "Why do individual users have to go through coordination for a system that is already coordinated?" Haller replied, "The FCC is looking at de-licensing of end-users."

The FCC handled questions on coordination fees by referring individual concerns on the fee structure to the appropriate coordinating body. The staff summarized that the FCC's open proceeding on frequency coordination includes examining the various fee structures.

Putting mobile's growth in perspective, panelists concurred that digital technology would enhance communications capabilities in 1990 and beyond.

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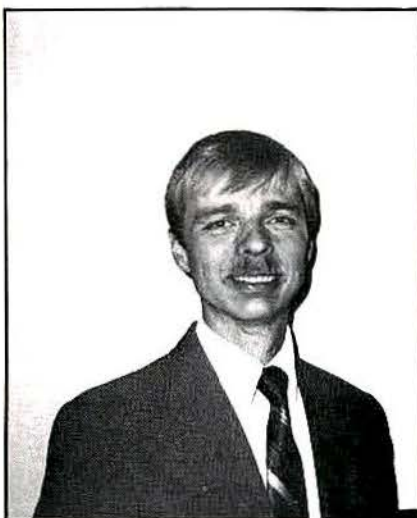
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Service manager wins *MRT's* \$1,000 'Case of Cash'

Donald Heidner, service manager with Electronic Specialties, Algona, IA, became \$1,000 richer when he won *MRT's* "Case of Cash" at the International Mobile Communications Expo in Las Vegas, NV.

Heidner and other contestants answered questionnaires by visiting exhibitors who had the correct responses to questions about *MRT* advertisers. On the last day of the convention, Heidner and other contestants watched as editorial director Don Bishop pulled the winning entry from a boxful of correctly answered questionnaires.

Heidner was all smiles as he received the \$1,000—and the briefcase in which the dollar bills had been on display in the *MRT/Cellular Business* booth.



Donald Heidner, service manager with Electronic Specialties, Algona, IA, wins *MRT's* \$1,000 'Case of Cash.'

Mobile Radio Technology

"Case of Cash" Questionnaire

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 - b) 99 number memory
 - c) keypad programmable
 - d) all of the above
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 - b) Federal Signal
 - c) Signal Measurement
 - d) Cambridge
3. How many digits will the decoder in Bramco's new 2981 SMART-MIC accept? (Booth #614)
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 - b) 2
 - c) 3
 - d) 8
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 - b) radar detector
 - c) antenna
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When you spend the extra time and effort to purchase your land-mobile communications products factory-direct, you might expect to save a little money. But the truth is, you probably aren't saving a dime. In fact, if you take a closer look, you could find you're working harder and actually *spending more* at the factory for the very same products you can get with one toll-free call to TESCO.

In a recent test conducted by a national, independent delivery-tracking firm, TESCO supplied product faster, more reliably, and more economically than the factory.*

To prove our point, we commissioned U.S. Monitor Service, an independent delivery-tracking firm, to place a typical cellular/two-way supply order, first with the product manufacturers, and then

with TESCO. In all, 10 well-known manufacturers were represented, so naturally, we expected some stiff competition. What we got, however, might surprise you.

The sample order placed with TESCO yielded a total cost savings of more than 15%, plus weeks in delivery time over factory-direct.

Because we stock products from over 70 top manufacturers, it took just 5 minutes and 1 toll-free call to place the sample order with us. To get the same items direct from the various factories took 10 calls (5 were toll calls) and over half an hour!

More importantly, TESCO had the items in stock. And we delivered everything in 1 shipment in just 2 days via regular UPS. The factory shipments, on the other hand, arrived sporadically, taking anywhere from 3 to as many as 42 days.

And because the factories had to ship 10 separate, smaller orders instead of just 1, shipping costs were an incredible 73% lower for the items ordered from TESCO.

But for those of you who swear by the factory for low prices, this last point may be the most surprising of all: TESCO's combined *item* costs were actually 13% less than the identical items ordered direct from the factory!

So go ahead, give TESCO a call today. You might just find we do it better, faster and cheaper than factory-direct.



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ENTELEC '89 conference boasts 30 technical papers

System planning, design, implementation and maintenance were among topics covered in sessions that explained communications problems and solutions. Bound copies of technical papers are available.

By Don Bishop
Editorial Director

Technical presentations, a Superdome floor with exhibits, catering from morning to night, elections and award presentations kept delegates to the Energy Telecommunications and Electrical Association (ENTELEC) conference in New Orleans busy March 19-22.

• **Sessions**—Program chairman Ron Amox and committee members amassed 30 hours of concurrent technical sessions. Those we attended made effective use of color photography, physical



Mike R. Yenik of Chevron Information Technology: "Temperature effects are more severe on lead-acid batteries than nicads."

samples and equipment demonstrations.

Sessions intended for general application across all disciplines included regulatory, lightning protection, battery, power transmission and licensing topics.

Supervisory control and data acquisi-

tion (SCADA), data and voice transmission, and RF transmission topics had specialized sequences.

At the sessions

Selected topics included:

□ **Batteries:** Chevron Information Technology senior communications analyst Mike R. Yenik reviewed stationary batteries commonly used in communications facilities, including Plante, lead antimony, lead calcium, lead selenium and nickel-cadmium (nicad).

"For a given ampere-hour rating, lead-acid cells are more efficient than nicad cells at producing long-term, low-rate current," Yenik said.

Nicad cells are physically stronger than lead-acid cells, though, making them more suitable for locations subject to high vibration. Yenik further stated: "Temperature effects are more severe on lead-acid batteries than nicads."

But nicads are "gassy": "For any battery plant capacity, nicads produce 10 to 22 times more hydrogen gas," he said.

□ **Grounding:** Henry Diaz of MCI, Richardson, TX, gave a fully illustrated talk about the grounding practices his company uses to protect its 900 microwave and fiber optic repeater sites.

Central to MCI's grounding approach is an earth electrode subsystem. "This is critical," Diaz explained, "because lightning always will look to earth for a discharge path."

The earth electrode subsystem consists, for the most part, of a buried ring around the facility. The ring is constructed of buried ground rods, interconnected by bare copper wire. The assembly is buried at a depth of 2.5 feet



David Hoxworth of Marathon Oil was elected as ENTELEC's new president.

to 3 feet, depending on soil conditions.

Diaz also covered tower grounding, grounding the shelter externally and grounding equipment within the shelter.

Northern Illinois Gas

Arnold Domanus Jr., a supervisor of control systems for Northern Illinois Gas, Aurora, IL, continued the theme with his paper, "Lightning Protection—What We Did." Equipment to be safeguarded from damage included low-voltage microprocessors used at sites with antennas on towers ranging from 120 feet to 400 feet high, and remote terminal units connected with antennas from 20 feet to 40 feet high.

As with the MCI installation, Domanus' approach included extensive grounding. One difference: At a Kankakee, IN, facility, Domanus in-

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Golay
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1989 officer and board member elections

The following ENTELEC members were elected or re-elected as officers and board members:

- ☐ **President**—David Hoxworth, Marathon Oil, Findlay, OH.
- ☐ **First vice president**—Ron Amox
- ☐ **Second vice president**—Offie Walker, Transcontinental Gas Pipeline, Houston.
- ☐ **Secretary-treasurer**—George Terry, Tenneco, Houston.
- ☐ **Board member**—William G. Carter, Colorado Interstate Gas, Colorado Springs, CO.
- ☐ **Board member**—Ricky Tuss, Du Pont de Nemours, Houston.
- ☐ **Board member**—Kenneth D. Hall, UNOCAL, Los Angeles.

stalled a brush-type ion dissipator near the top of the tower. When questioned, he said he could not attest to its effectiveness.

For example, grounding techniques had been sufficient to control damage at the other sites. At the Kankakee facility, damage caused by lightning strikes ceased when the grounding system and ion dissipator were installed. Whether the grounding was sufficient to safeguard the equipment or the ion dissipator provided a necessary extra measure of safety Domamus could not say, "because we did not unhook the dissipator to see what would happen."

Bound copies of 30 conference papers are available from ENTELEC headquarters; call 214-235-0655. The publication of conference papers in a single volume is a practice other conventions would be well advised to follow.

• **Exhibits**—Under the Superdome roof, about one-third of the exhibits seemed to be for two-way radio com-

CW IDENTIFIER AND SITE MONITOR



ID/SM-700
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Data Signal's new CW Identifier with Site Fault Monitor capability surpasses all other CW identifiers with its versatile, user-programmable microprocessor design. The ID/SM-700 parameters are field-programmable with dip-switches and a keypad supplied with the unit, thus eliminating the need for one-time programmable PROMS.

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Data Signal's new Rural Telephone System, the RTS-25 will extend a telephone to any remote area. It is ideal for use in remote interconnects, drilling rigs, ranches, mines, cabins, etc. A standard rotary or DTMF telephone set can be used at the remote location. The RTS-25 will ring any standard telephone set. The unit is designed to automatically function with a rotary or DTMF telephone exchange. The RTS-25 is sold as a set and includes both the telephone exchange and the remote terminal units.



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J.C. Smith (left), an ENTELEC honorary member, receives the association's Directors Award from outgoing president Carl R. Bailey in recognition of Smith's enthusiastic service to the organization.

munications users, one-third to SCADA users and one-third to microwave communications users.

• **Catering**—Food service made an unusual contribution in stimulating exhibit traffic. Conference registration included a buffet breakfast each morning, an exhibit-floor lunch the first day and a luncheon the second day.

Thus, the catering arrangements encouraged delegates to arise in time for the morning exhibit hours and to remain in the Superdome during lunchtime—clever idea!

• **Elections**—David Hoxworth of Marathon Oil, Findlay, OH, advanced on schedule from first vice president to president, succeeding Carl R. Bailey of Chevron Information Technology, Houston. Other election results appear in the box on page 42.

• **Awards**—J.C. Smith of J.C. Smith and Associates received the ENTELEC Directors Award for his contributions to enhance the stature of the association, its members and the industry. The

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DB201 Ground Plane (30-512 MHz) and DB205 Coaxial (30-174 MHz) are unity gain omnis for local paging.

External dipoles (406-512 MHz), with 3.8 to 12 dB gain, include DB404, DB408 (pictured), DB411, DB413, DB420 (450-512 MHz), DB224 and DB264 (148-174 MHz).

DB212 Side Mount Antennas (33-88 MHz) offer 3 to 12.1 dB gain.

DB230 Directional is field tunable with 7 dB gain. DB225 has 5 dB gain. Both are 33-174 MHz.

Full-Wave-Dipoles DB803/6/9-K Antennas are 3, 6 or 9 dB gain omnis for 928-932 MHz paging.

DB559-G Aeroglas™ Omni (928-932 MHz) provides 9 dB gain with 3°, 6° or 10° of electrical downtilt. DB557 has 7.5 dB gain. Several VHF and UHF Aeroglas omnis cover paging needs.

DB561/4-G Directionals (928-932 MHz) provide 11 to 14 dB gain, 120° to 170° coverage, optional downtilt.

DB205



DB201

DB225

DB230

Field Tunable!

DB559

DB809

DB561/4



DB4042 Bandpass Cavity reduces interference in 30-50 MHz.

DB4345 High Power Ferrite Circulator, with heat sink, reduces interference in 928-940 MHz.



DB8061WB-E permits isolator/cavity protection to a stand-alone Tx or the addition of 900 MHz paging to an existing Tx combiner.



DB4001 (148-174 MHz) and DB4011 (66-88 MHz) and DB4021 (450-512 MHz) have one, two or three bandpass cavities.



DB4700 Series of Ferrite I.M. Panels uses single or dual isolators for 148-174, 450-512 or 928-932 MHz protection.



Decibel carries HELIAX foam and air dielectric cables, also superflexible HELIAX.



Decibel offers 100, 125, 150 and 200 watt power amplifiers.



New DB8830 Sentry Remote Monitor for one or two Tx.



New DB8820 TxLAM™ Single Tx Local Alarm Monitor.

DB8860 Sentry™ Remote Site Monitor, with accessories, reports and controls up to 64 Tx/antennas. (Not pictured.)

Factory Authorized Warehouses: Tekcom, Inc., Costa Mesa and Union City CA; Talley Electronics Co., Hayward CA, Santa Fe Springs CA and Phoenix AZ; CW Electronics, Denver CO; The Antenna Farm, Overland Park KS; M. Hutton Co., Dallas TX; ComMar, Inc., Westport MA; Tesso, Inc., Hunt Valley MD; Tampa FL; Schaumburg IL, and Sparks NV; Primus Electronics Corp., Joliet IL; Cartwright Communications Co., Cincinnati OH. International: Marketronics, Sunrise FL (for South America); Lenbrook Industries, Ltd., (Canada) St. Leonards, Quebec; Calgary, Alberta, and Pickering, Ontario; RAC, (Italy) Milan; Walmore Electronics, Ltd., (England) London; OmniTronics Enterprises PTE Ltd., (Singapore); Sistemas Profesionales S.A., (Mexico) Mexico City; R.F. Devices Pty., (NSW Australia) Miller. Visit Decibel at UTC Booth #277.

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Decibel antennas provide maximum power handling, area coverage and gain for all paging frequencies: 30-50, 66-88, 148-174, 450-512 and 928-932 MHz.

For local areas, Decibel offers 500-watt, unity gain, omnidirectional antennas that are rugged yet inexpensive.

Gain antennas include omni Aeroglas™ and external dipoles, also directional side mounts and field-tunable Yagis.

Decibel's metal antennas, made of welded 6061-T6 high strength aluminum alloys, are 99% immune to static and lightning.

For 928-932 MHz paging, Decibel offers: omni fiberglass Full-Wave-Dipole (FWD™) antennas with 3 to 9 dB gain, also Aeroglas™ omni and directional antennas with up to 14 dB gain and optional downtilt.

Aeroglas — a process used for Olympic vaulters' poles and racing sailboat masts because of its strength and light weight — is a Decibel exclusive for radome use!

The Finest Transmission Lines

Decibel offers all the necessary hardware and connectors — fitted or unfitted — along with high quality low-loss HELIAX® coaxial cables. These include 1/2" to 1 1/2" foam and 7/8" to 2 1/4" air dielectric as well as 1/4" and 1/2" superflexible HELIAX. Circle (44) on Fast Fact Card

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Power Amplifiers

Decibel now offers new, continuous duty power amplifiers with 100, 125, 150 and 200 watt ratings. Customized amplifiers are also available for special requirements.

Remote Site Monitors

With Decibel's selection of Sentry™ Remote Site Monitors, you can monitor, protect and control paging transmitter sites with one to 64 Tx/Antennas! This means (1) more up time, (2) less routine maintenance, and (3) lower repair costs.

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If you want quality, you want Decibel! Leadership since 1947.



Fred M. Link (right), an ENTELEC honorary member and MRT's industry consultant, receives the National Service Award presented by Ray Thrower as president of the National Association of Radio and Telecommunications Engineers.

presentation was made during the awards banquet.

MRT industry consultant Fred M. Link received an award during the luncheon, although the award was made on behalf of another organization. The National Association of Radio and Telecommunications Engineers gave Link its National Service Award. The award recognizes Link's accomplishments as one of the first manufacturers of radio communications equipment.

NARTE president Ray Thrower, in presenting the award, cited Link's employment of blind workers during the 1940s as an example of his progressive leadership.

NARTE set aside a \$1,000 scholarship in the association's and in Link's name in connection with the award. Link may assign the scholarship to the school of his choice.

Smith and Link are the only two "supplier" members of ENTELEC to have been elevated to honorary membership in the association.



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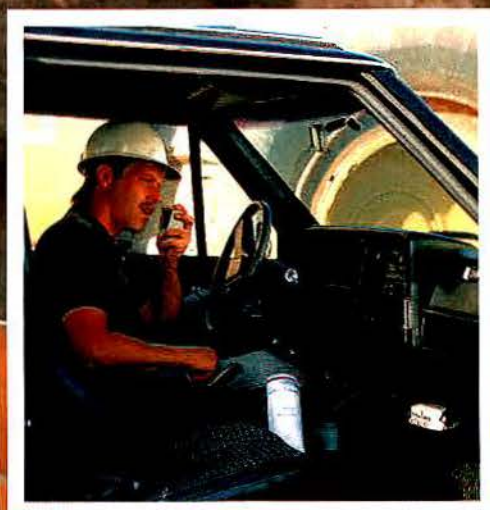
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Circle (46) on Fast Fact Card

Paging coverage vs. frequency

Part 2—Cliches about paging system coverage bear a measure of truth; for example, that different coverage characteristics may be expected from different frequency bands. Here are some reasons for the differences.

By Jim Hathaway
and Roy Holmes

Ever heard these opinions about paging system coverage?

"For wide-area paging, you can't beat VHF, especially lowband."

"UHF may not give long range in some cases but, for building penetration, it can't be beat."

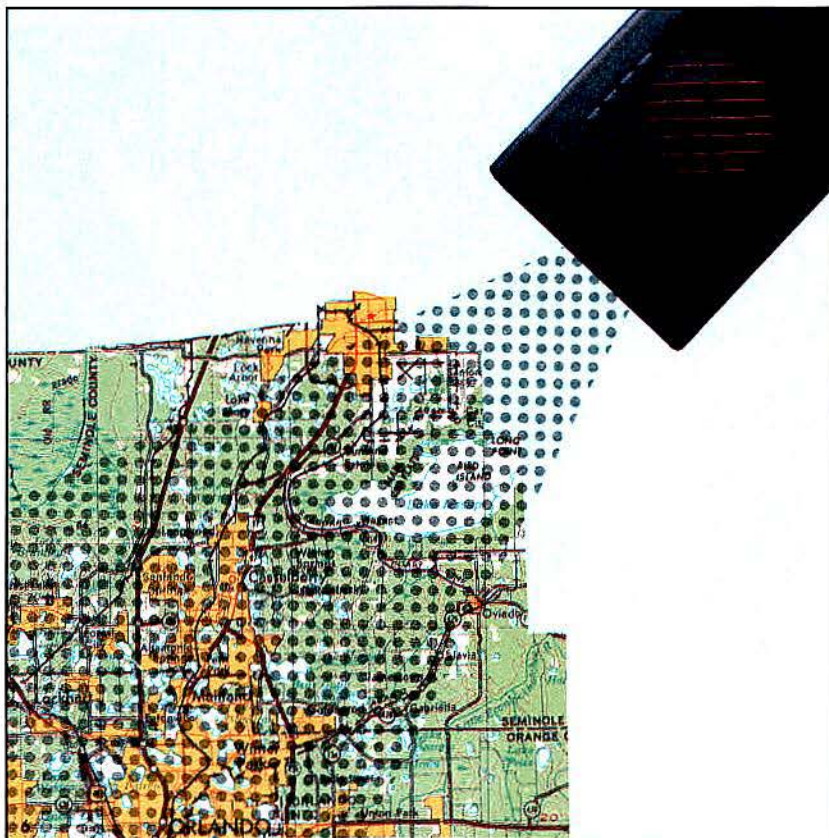
(Paradoxically): "900MHz doesn't penetrate, which is why it gives such building penetration."

Defining coverage

"Coverage" means something different to each system operator. Selecting an operating frequency depends in part upon the coverage desired and, therefore, the definition of "coverage."

For most operators with systems in small towns or rural districts, coverage means the square-mile area where pages are received reliably. The size and composition of structures within that area are *relatively* unimportant.

Hathaway is the technical writer and advertising manager at Reach Electronics, Lexington, NE. Holmes is a senior engineer.



For many operators with systems in large cities, coverage means reliable reception inside office buildings, factories, subbasements, tunnels and automobiles, as well as at street level.

Generally speaking, pagers used in sight of the transmitter receive perfectly because air has little effect upon the signal. This reception is called "line-of-sight" propagation.

But most pagers receive signals when eclipsed from view of the transmitter by structures, terrain features, the earth's

horizon or a combination of factors. Other propagation modes direct the signal by alternate paths or through solid objects:

- **Diffraction**—the diffusing of the signal around an object.

- **Refraction**—the bending of the signal by the atmosphere, extending its reach to areas beyond the horizon.

- **Reflection**—the rebounding of the signal from the surface of an object, sometimes improving reception, sometimes weakening reception.

- **Penetration**—the passing of the signal *through* a solid object. As it

passes, it is partially or entirely *absorbed*.

Absorption and reflection tend to be greater at higher frequencies. Thus, lower-frequency signals that reach pagers inside structures tend to do so by passing through the building materials. Higher-frequency signals that reach inside structures tend to do so by entering through windows and reflecting along walls and through doorways.

Foliage absorbs UHF signals, especially those in the upper UHF

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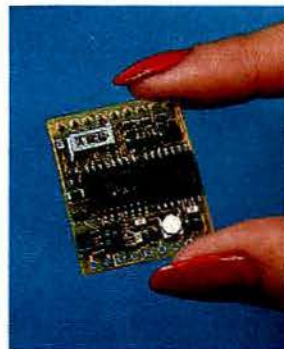
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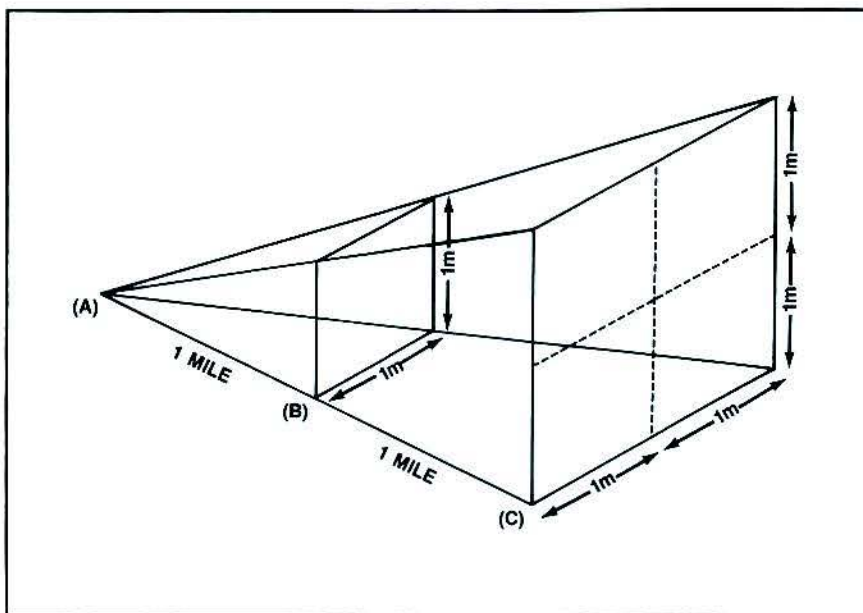


Figure 1. Radio wave moves outward from source (A). If at (B) its strength measures $100\mu\text{V/m}$, then at (C) its strength is one-fourth: $(100\mu\text{V/m})/4 = 25\mu\text{V/m}$.

range. Absorption is the greatest when leaves contain the most moisture.

Compared to UHF, lowband VHF

penetrates foliage much better because its wavelength is 30 times longer. If the leaves were 30 times larger, lowband

VHF would suffer higher absorption by foliage.

Spatial attenuation

Distance alone affects signal strength. The signal weakens as it travels away from the transmitting antenna, as shown in Figure 1 at the left. In the example, the signal's source is point (A). At 1 mile from the source, the signal is measured at a relative strength of 100 microvolts per meter, or $100\mu\text{V/m}$.

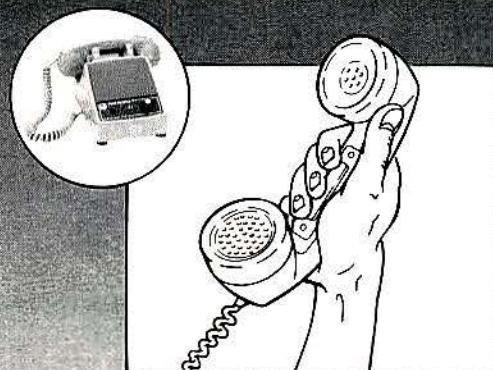
At point (C), 2 miles—twice the distance—from the source as point (B), the signal is one-fourth its strength at point (B) in each of the 1-meter-square (1m-sq.) areas shown as shaded squares in perspective.

The radio wavefront has spread out over an area equal to twice the distance squared (2^2), an area four times as large. A signal measurement taken at this distance would read $25\mu\text{V/m}$.

Horizons and obstructions

When looking toward the most distant point on the earth's surface within view,

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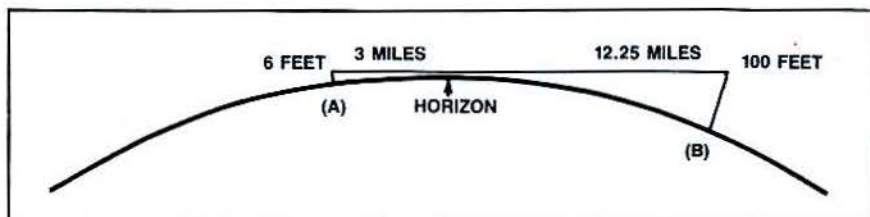
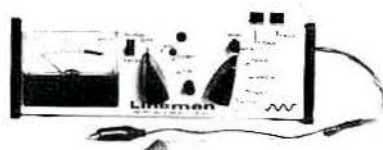


Figure 2. Viewed from an eye level 6 feet above the ground (A), the 'geometric horizon' is approximately 3 miles away. Viewed from a vantage point 100 feet above the ground (B), the 'geometric horizon' is approximately 12.25 miles away.

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a casual observer sees the "apparent horizon," which is where earth and sky appear to meet.

A "geometric" horizon is where the earth and sky *would* appear to meet if the earth were *smooth*. In other words, hills, mountains and city skylines are excluded.

On a smooth earth, as on a calm sea or "flat" land, a person whose eyes are 6 feet above the surface would see the "geometric horizon" about 3 miles away. (See Figure 2 at the left.) From a point of observation 100 feet above the surface, the geometric horizon would be 12.25 miles away.

A 400W lowband VHF signal broadcast from an antenna 100 feet above ground may activate a pager as far away as 16 miles to 18 miles or more. The reason why it may reach beyond the geometric horizon 12.25 miles away is because the atmosphere refracts a portion of the signal and bends it around the earth's curvature.

On the other hand, little of a 900MHz UHF signal refracts around the earth's



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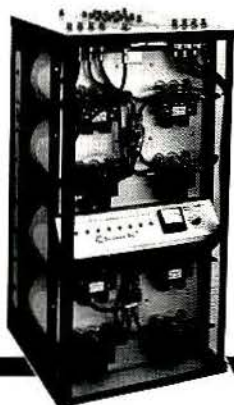
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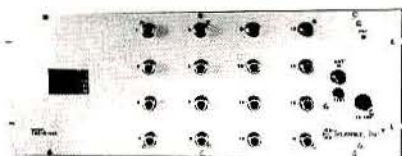
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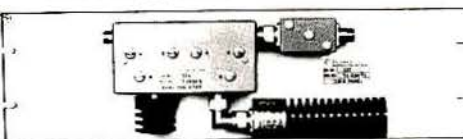
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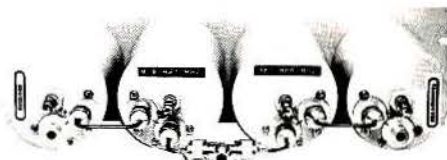
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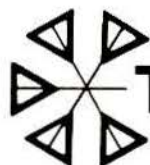
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curvature. Its paging range conforms more closely with the distance to the geometric horizon.

Suppose a sharp ridge blocks the view from the transmitting antenna to the geometric horizon. Instead of refracting to reach beyond the geometric horizon, the signal diffracts, reflects or both, possibly extending coverage behind the hill. Diffraction—which diffuses the

signal, directing a portion of it toward the ground behind the hill—is greater at lower frequencies. Thus, at upper UHF frequencies, diffraction is less helpful to cover areas behind hills.

A ridge's profile may be non-uniform. Radio waves striking it in different places may be redirected to the same pager by multiple paths. The resulting wave interference pattern, known as

multipath interference, produces random nulls and peaks in received signal strength. Nulls can reduce paging coverage greatly.

UHF is much more adversely affected by multipath reception than VHF.

Downtown and industrial areas in large cities have abundant artificial sharp ridges at all angles as parts of structures. Multipath interference that results from diffractions and reflections in these areas can be perplexing. Conversely, diffractions and reflections may extend UHF coverage to some places that VHF signals cannot reach.

Building penetration

Another cliché: "You just don't get good building penetration with SCA."



Cornhusker Paging, Columbus, NE, and Cornhusker Public Power District share a subcarrier on FM broadcast station KZEN, Central City, NE. KZEN's antenna is 1,854 feet high on a TV station's broadcast tower near Columbus.

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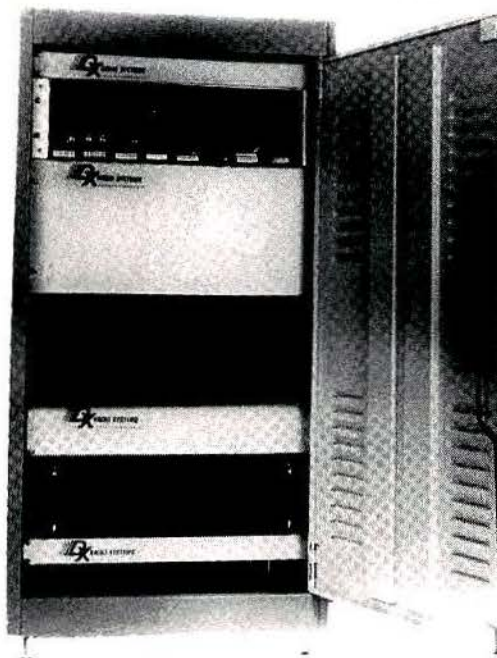
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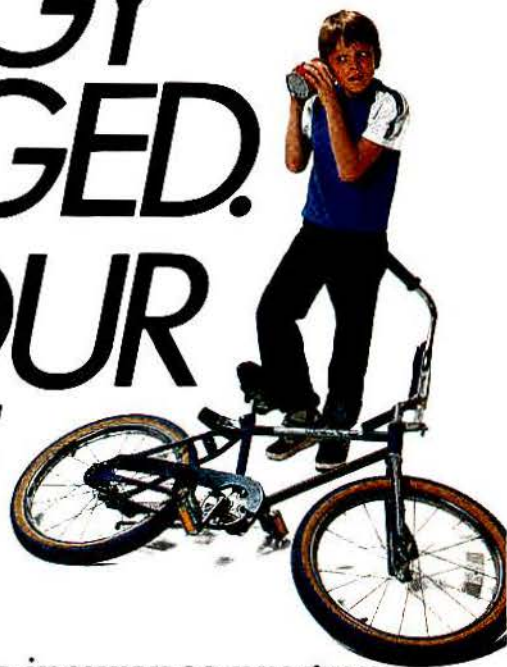
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SCA refers to subsidiary carrier authorization, or subcarrier. As part of a broadcast station signal, a subcarrier may be used for paging. In practice, only FM broadcast station subcarriers are used for paging.

FM stations use frequencies between 88MHz and 108MHz. To understand the cliché is to understand that a comparison is being made between a 100MHz signal and some other signal, usually 900MHz. Signals at 900MHz have a reputation for penetrating buildings better than 100MHz signals

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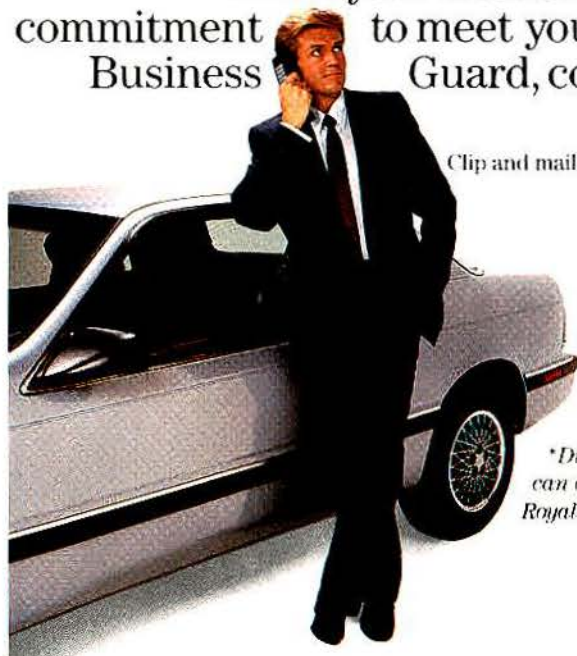
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Paging power

An SCA paging signal's share of a 100,000W FM station's power may be:

- ☐ 332W (92kHz subcarrier at 10% injection)
- ☐ 625W (67kHz subcarrier at 10% injection)
- ☐ 2,483W (67kHz subcarrier at 20% injection)

When comparing one SCA system to another, it is essential to specify subcarrier frequency, injection percentage and antenna height. The three determine the signal strength delivered to the pager.

do, although that is not always the case.

Years ago, when most pagers used lowband or highband VHF, discussions of building penetration were uncommon. It was not unusual for VHF systems to reach pagers used inside buildings, including basements and subbasements.

In the early 1970s, for example, a transmitter in Chicago's Clinton Realty Association building offered suitable building penetration with our highband VHF tone-and-voice pagers.

But so many new systems are built to use UHF and 900MHz UHF frequencies, the issue of building penetration at

VHF vs. UHF is debated more often than before. Operators of new citywide paging systems want to cover each individual, specific building. The system design must overcome any harmful effects of diffraction, reflection and multipath propagation interference.

UHF signals do not penetrate most building materials well, other than non-metallic (non-reflective) glass, to enter building interiors. In contrast, VHF signals penetrate building materials better (with some absorption), but their wavelengths may be too long to take advantage of openings afforded by windows.

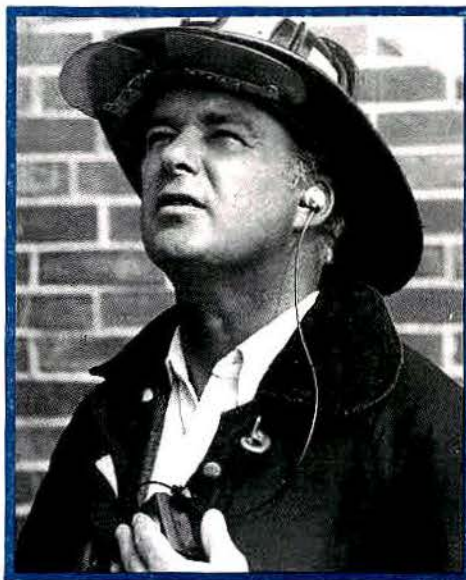
Therefore, if a structure has windows, UHF signals may enter, bounce around the interior, reflect along hallways and into offices and other working areas. For a radio signal to pass through a window and undergo little absorption, it must have a half-wavelength shorter than the window dimension. Table 1 on page 62 lists half-wavelengths for selected frequencies.



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If a window opening measures at least 3 feet, a 150MHz signal can penetrate. But a 35MHz signal, with its 14-foot half-wavelength, is absorbed and reflected by material surrounding the window. The lowband signal may penetrate, but a weaker signal reaches the interior after the wall absorbs some of its power.

Some exterior walls of modern office

buildings are made of reflective glass. Others have no windows, or their windows face away from the paging transmitter. Some cities are hilly, so no single antenna can provide full coverage. None of these problems is an actual range problem, though.

SCA paging coverage

An important difference between SCA

paging and conventional paging lies in the selection of the antenna site, effective radiated power (ERP) and operating frequency.

With an SCA system, especially in smaller towns, choices are limited. Nonetheless, in evaluating the potential for using an SCA, it is better not to concentrate on any one particular weakness because all system designs have trade-offs.

For example, one paging system operator upgraded a system by moving it from one FM station SCA to another. The first FM station used a nearby, low-power transmitter. Its SCA delivered satisfactory building penetration because the broadcasting antenna was so close to town. But the entire coverage radius was only 10 miles.

The operator relocated the paging system to an SCA on a 100,000W FM station with an antenna nearly 2,000 feet above average terrain. The coverage area expanded to a 40-mile radius. But building penetration in town did not improve, because the antenna is farther away.

Power radiated from the antenna does not activate the pager; signal strength at the point of reception does. Signal strength diminishes as the square of the distance from the source.

SCA paging power

Only a small portion of the FM broadcast signal forms the SCA paging signal. Its actual power is limited by two factors: the subcarrier frequency and its injection percentage relative to the broadcast signal.

Injection percentage refers to the deviation of the subcarrier on the main channel that carries it. Subcarrier deviation is small, compared to the total deviation of $\pm 75\text{kHz}$ maximum for 100% frequency modulation. The total deviation includes modulation by the broadcast program audio and by the subcarrier.

For SCA paging, FCC rules permit a maximum injection percentage of 20%, equivalent to $\pm 15\text{kHz}$ deviation. The maximum deviation is permitted for the 67kHz subcarrier when it is the only subcarrier in use.

At 92kHz, injection is limited to 10% ($\pm 7.5\text{kHz}$ deviation).

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Table 1—Half-wavelengths at selected frequencies.

BAND	TYPICAL FREQUENCY	APPROXIMATE HALF-WAVELENGTH
Lowband VHF	35MHz	14 feet
SCA	100MHz	5 feet
Highband VHF	150MHz	3 feet
UHF	450MHz	13 inches
UHF	900MHz	6.5 inches

their total injection is limited to 20%.

Therefore, to reach maximum paging signal power in an SCA system, a sub-carrier frequency of 67kHz is used.

Fact

A little-known fact: When the same

injection percentage is used in the 67kHz and 92kHz subcarriers, the 67kHz subcarrier has 2.75dB more power than the 92kHz subcarrier.

Put another way, at 10% injection, the 92kHz subcarrier has 73% of the power compared to the 67kHz subcarrier.

At a 100,000W FM station, the actual "paging power," meaning the subcarrier's share of the total broadcast signal, may range from a mere 332W (92kHz subcarrier at 10% injection) to 625W (67kHz subcarrier at 10% injection) to 2,483W (67kHz subcarrier at 20% injection).

The best way to predict how well a paging system will deliver the desired "range" and "coverage" is to conduct field tests. Test pagers, custom-built by the manufacturer for the purpose, may be borrowed for field tests.

So much has been said and written about paging coverage that system operators should evaluate SCA paging for themselves and for their particular service areas. What tells the story is not the pager's numerical specifications. It is not the numerical specifications of the FM broadcast station transmitting system. What tells the story is the result of field testing. Testing requires time and effort. But the results are worth it.



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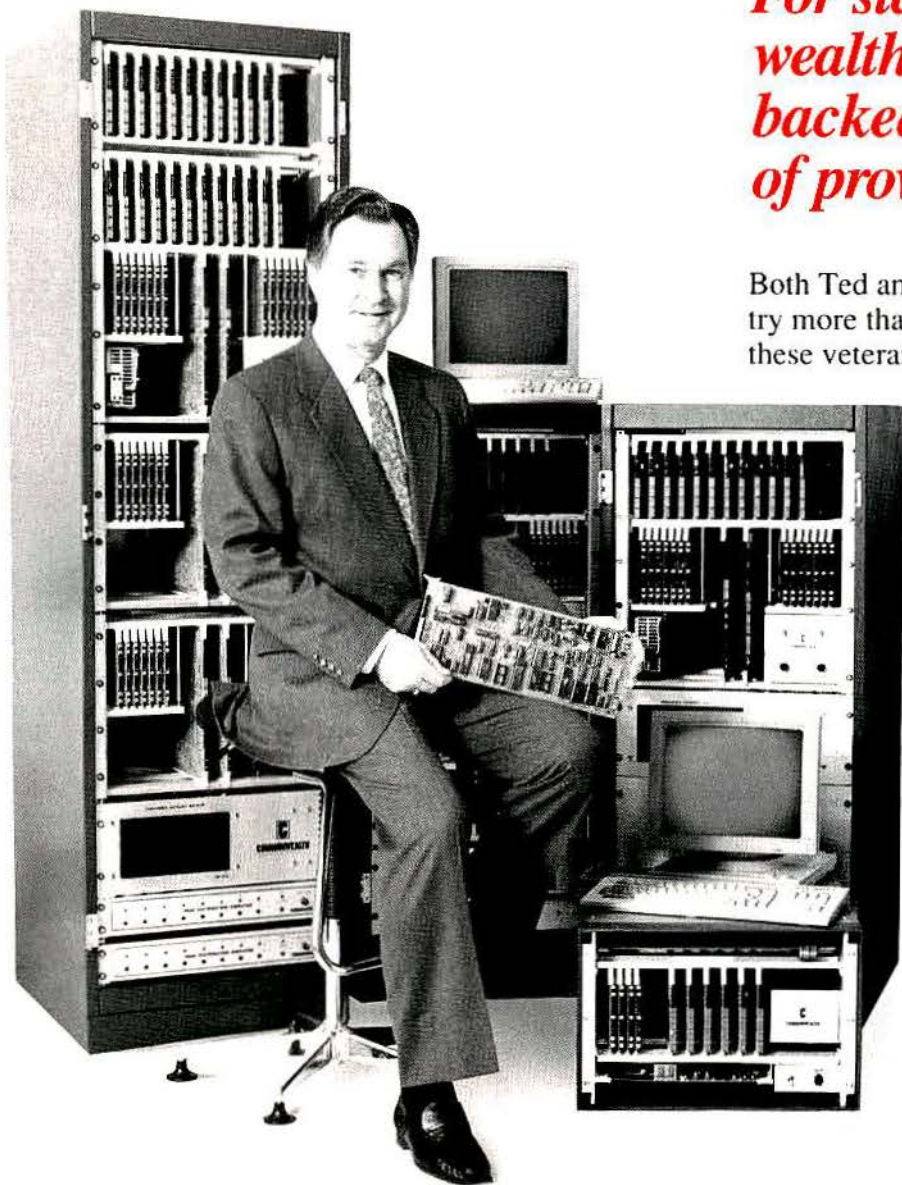
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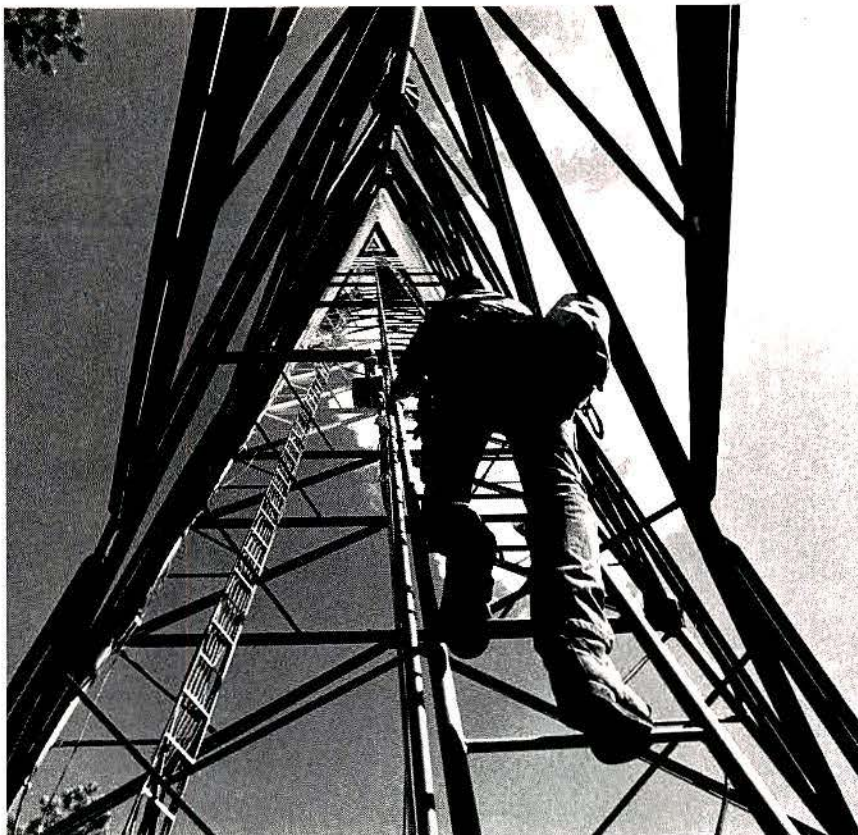
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Two-way system operators meet to hear technical advice

An estimated 300 two-way radio system operators met in Orlando, FL, Jan. 30 and Jan. 31 to attend a new technologies symposium and manufacturer exhibition. The event was sponsored as a membership meeting of the American SMR Network Association, a Washington, DC-based trade association of specialized mobile radio (SMR) system operators.

Coverage extenders

Ray Collins of Telewave, Mountain View, CA, and Dan Kaegebein of



Bruce LeVasseur, D & L Communications, Fort Wayne, IN: 'You cannot prevent lightning strikes.'

TX RX Systems, Angola, NY, spoke on the subject of coverage extenders.

"After you have selected your site," Collins told the audience, "then your problems begin!"

If the site is a rooftop, coverage and operating challenges may be posed by surrounding obstacles including other buildings and antennas. If the site is a mountaintop, configuring the antenna to deliver sufficient signal near the base of the mountain may be tricky.

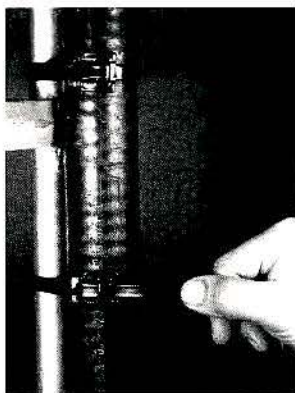
Antenna emission patterns may be affected by mounting positions below the top of the tower, Collins said. But tower-top positions may allow the wind to flex the antenna, distorting its pattern. "Movement may create 6dB to 10dB variations in gain in a particular direction," he said.

Component heat affects receiver sensitivity, so Collins advised his audience to "spend money on air conditioning

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and keep the equipment cool." For those who wanted to evaluate the effects of heat, Collins suggested making sensitivity measurements in the cool of the night and comparing them with measurements made during the heat of the day.

Kaegebein explained the configura-

tions of broadband, bi-directional repeaters used to extend coverage into areas of high signal attenuation, such as large buildings, tunnels and mines.

Technical advances

Wayne Lafitte and Coy Davis of Decibel Products, Dallas, and Bob

Perelman of Andrew, Orland Park, IL, spoke about technical advances.

Lafitte reviewed his company's remote site monitoring product, the Sentry.

Perelman explained electrical and mechanical considerations involved in selecting coaxial cable products, in-

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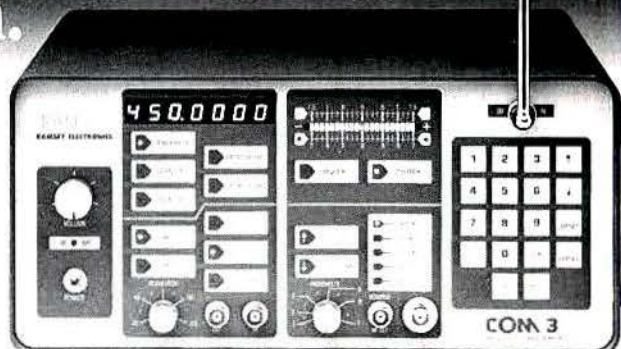
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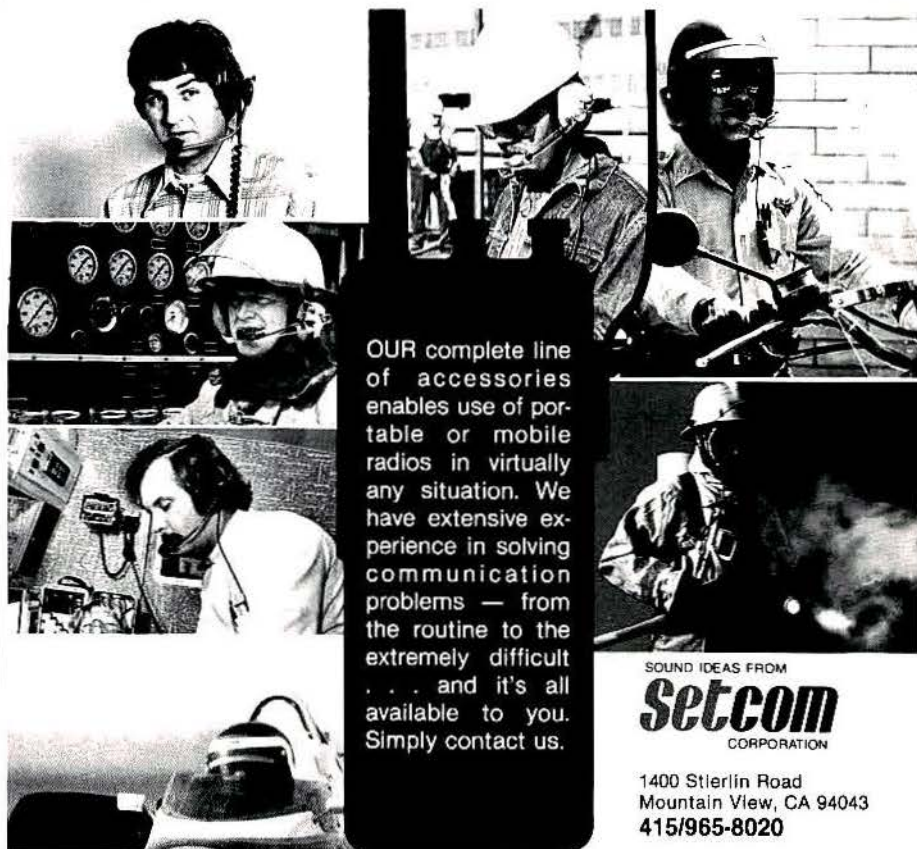
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cluding the attenuation and cost factors.

Davis gave a rundown on the available antenna site equipment configurations for 900MHz SMR systems. Because 900MHz licenses are granted for adjacent frequencies, transmitter combining options are limited. Moreover, the more transmitters that are combined to a single antenna, the greater the combiner losses.

Antenna site managers tend to want to reduce the number of antennas to a minimum. Davis gave some details about an antenna product that includes three operating elements within a single



Mark Abrams, Raycom, Los Angeles: 'Every dollar you save in installation is likely to cost you \$3 down the road.'

radome to make the three antennas look like one.

Site maintenance

Bruce LeVasseur of D & L Communications, Fort Wayne, IN, and Mark Abrams of Raycom, Los Angeles, spoke about site maintenance issues.

LeVasseur focused on lightning protection, drawing heavily from material written by Roger R. Block of PolyPhaser, Gardner, NV. "You cannot prevent lightning strikes," LeVasseur said, "so the concept is to control and direct a lightning surge so it does the least amount of damage."

He said ground leads should be short, fat, straight and clear of metal, and should be directed downward. In contrast, leads not intended to carry surge current may be coiled or directed upward to increase their inductance relative to the surge.

Abrams, who illustrated his talk with slide photos of "good" and "bad" site

configurations, said, "Every dollar you save in installation is likely to cost you \$3 down the road." His example of an ideal site included:

- open frame racks. "Equipment runs cooler and is easier to access. Lighting and space utilization are better," he said.
- chain link fence for security.
- interior electric meters to avoid vandalism.

• crushed gravel ground cover to avoid mud, promote appearance and eliminate periodic weed cutting.

• outside lighting for "inevitable nighttime work."

• separate transmitter combining and receiver multicoupling to reduce the number of antennas. "Space on your tower runs out long before space in your building," he said.

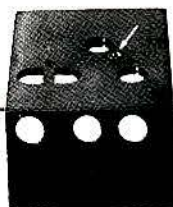
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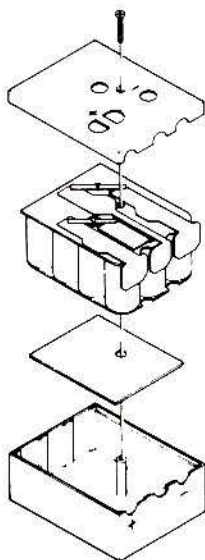
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Abrams illustrated a receiver multicoupler configuration that uses two stages of GaAs FET pre-amplification. But rather than cascading two pre-amplifiers ahead of two stages of signal splitters, Abram's specification uses one pre-amplifier to feed the first four-way

splitters and four more pre-amplifiers to feed four more four-way splitters.

The method increases receiver sensitivity and reduces susceptibility to overload. "It costs \$600 more, but it is well worth it," Abrams said.

Tellular wins injunction in 'West' patent case

Tellular, Wilmett, IL, won a permanent injunction in a patent infringement suit against Morrison & Dempsey Communications, Northridge, CA, for the sale of its AB 1X, AB 3X and AB 3XR interfaces. Morrison & Dempsey has been selling these cellular interfaces that

permit cellular phones to operate with standard data and voice communications products. Tellular owns rights to the "West" patent, which covers interfaces. At press time, damages had not been determined. Morrison & Dempsey was expected to appeal.

Genesis Group forms telecommunications division

The telecommunications division of the Genesis Group has been formed to provide services to the SMR industry. The company offers help with data

operations and management of Motorola SMR systems. The company may be reached at P.O. Box 131975, Tyler, TX 75713-1975; 214-561-6673.

CTIA endorses digital for cellular telephones

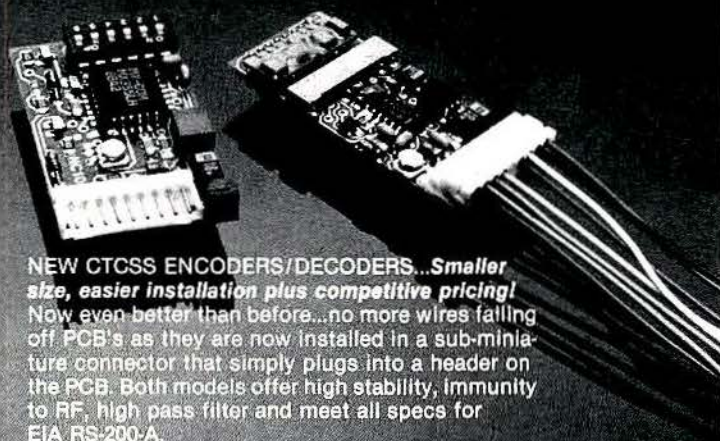
The Cellular Telecommunications Industry Association (CTIA), Washington, DC, has sanctioned the use of time division multiple access (TDMA) for the next generation of cellular telephones.

An advantage of digital cellular is that calls are private and immune to eavesdropping. Digital cellular also can support more calls per channel. The increased capacity will be needed if cellular's growth continues to accelerate as projected to more than 10 million subscribers by 1993.

Antenna Specialists begins European distribution

Antenna Specialists, Cleveland, and Innovative Trade Resources, Paris, have formed Antenna Specialists Europe to distribute Antenna Specialists' products to the European Economic Community.

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Lightning Master receives UL listing

Lightning Master, Brooksville, FL, has obtained an Underwriters Laboratories (UL) listing for its PP-35T static

dissipating air terminal. The product now can be used as a component in a "Master Label" installation.

Amateur radio organization promotes no-code license

Efforts to amend FCC rules to permit certain amateur radio licenses to be issued to applicants without a demonstration of Morse code proficiency has led to the formation of the National Amateur Radio Association (NARA). The founding members are NARA president Donald L. Stoner, Fred Maia and Terry Dettmann.

The average age of American amateurs is rising, Stoner said, and an increasing anti-technology bias in the United States is leading to a decrease in technical education. The two phenomena can be addressed, if not reversed, by encouraging younger individuals to participate in amateur radio activities. A license free of a Morse code requirement is expected to be more ap-

pealing to those younger potential amateurs.

"NARA's objective is to make amateur radio more widely known and to encourage more people to take up the hobby," Stoner said. To reach the objective, NARA proposes:

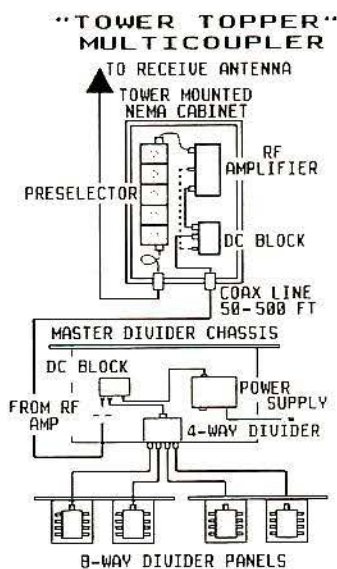
- to encourage the establishment of a code-free entry-level license.
- to create a youth-oriented program to advance technical education through amateur radio.
- to promote amateur radio to the general public through letters, articles and news releases.

The NARA headquarters is at 16541 Redmond Way, Suite 232, Redmond, WA 98052; 206-881-1949.

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Circle (73) on Fast Fact Card

Debate on paging use for illegal drug deals continues

The National Association for the Advancement of Colored People (NAACP) has petitioned the FCC to initiate a rulemaking proceeding intended to impede the use of FCC authorized paging devices in the illegal drug trade. Common carrier and private carrier devices are stipulated in the proposal.

Six steps are proposed to limit the use of land mobile radio equipment use by drug traffickers. Among the suggestions are to place restrictions on the sale and rental of pagers to persons under age 21.

Another proposal is to impose a two-week waiting period before a sale is made, and in that time, the seller would be required to verify the name and address of the potential customer and determine whether the person has a criminal record. Another part of the proposal calls for prohibiting certain types of sales such as weekend usage only.

Joining the paging use restriction

bandwagon, the Chicago City Council has proposed an ordinance that would require paging system users within the city to apply for a license. The proposed cost is \$50.

A Maryland congressman announced his intent to introduce a bill that would order to FCC to regulate paging use and pager possession by minors—those under 21.

The representative, Kweisi Mfume, said that the use of pagers for legitimate reasons by those under 21 would be allowed. He contends that minors involved in the sales and distribution of illegal drugs are relying on pagers to arrange drug deals.

Meanwhile, Telocator, a trade association representing paging and mobile phone interests, objects to the proposed NAACP petition and will object to the Mfume legislation, if introduced.

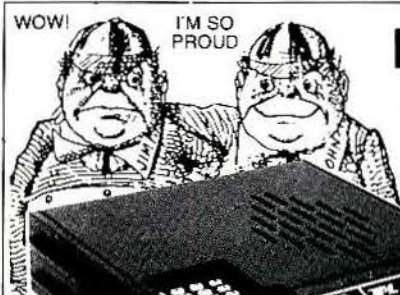
A Telocator spokesman said that

refusal of service to those under 21 and cloning all pagers, which is a suggested remedy, raises questions about discrimination and violations of privacy. The association has met with the NAACP to discuss its objections to the petitions and plans other meetings. It also plans to meet with Mfume to dissuade him from introducing legislation he is reported to be considering.

Pagers can be used to capture criminals engaged in illegal activities through cloning or recording information about pages as they are sent, Telocator points out. Because pagers can, in effect, be used against criminals, their usage in crime could drop dramatically as criminals become aware of the dangers of being caught, Telocator asserts.

The paging association appears determined to fight restrictive paging legislation.

Telocator plans to educate RCCs and law enforcement agencies in how to use pagers to capture criminals.



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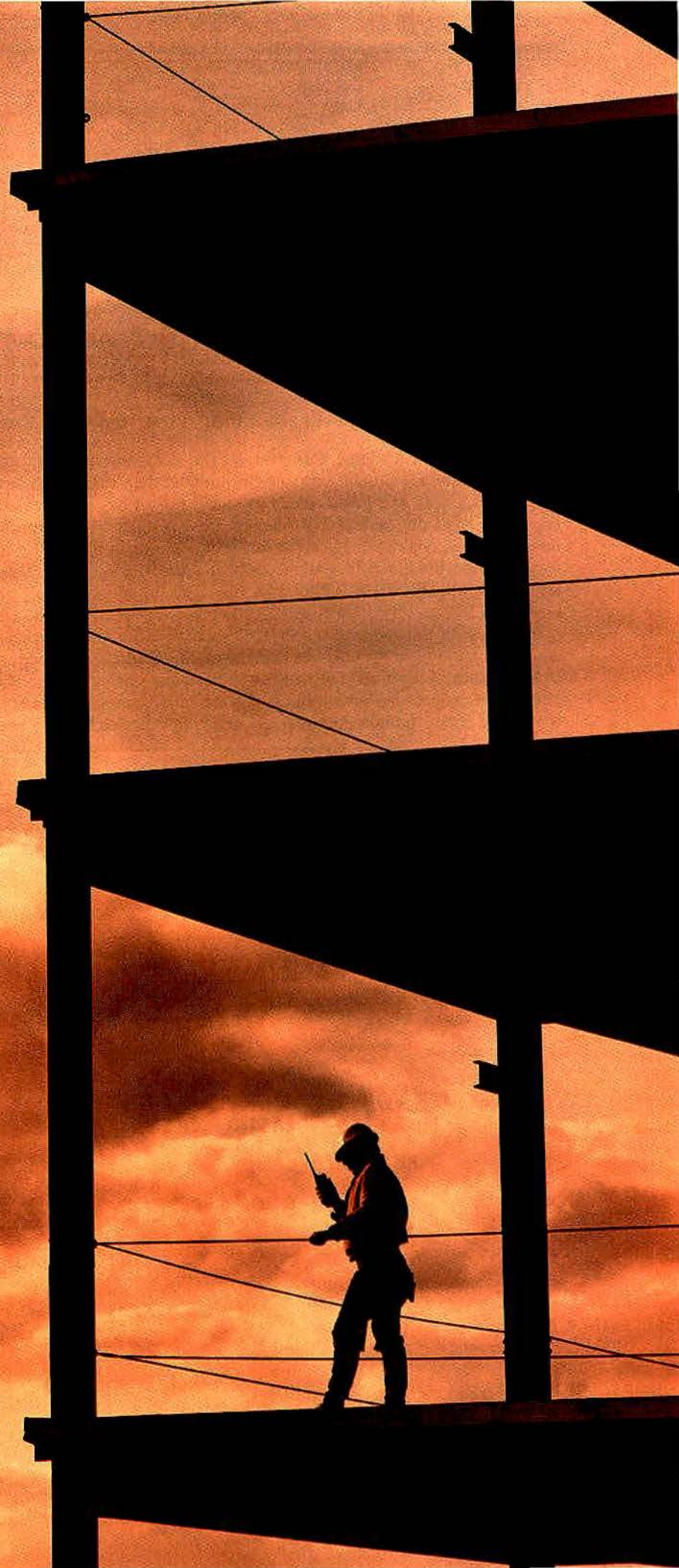
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Uniden, Americom sign pact for mobile

Uniden, Fort Worth, TX, is developing a 900MHz mobile radio that will work on Americom's wide-area dispatch and mobile telephone networking system. Americom, Atlanta, will provide Uniden with a control logic board to install into Uniden radios to make them compatible with Americom's system.

Uniden has been working in coopera-

tion with Americom for three to four years. Americom has been operating its systems for more than 1½ years and has more than 30 systems in operation.

Uniden's SMS series mobile joins its full-duplex 800MHz SMS 300TSD mobile as Americom-compatible radios. Uniden expects to begin delivering the mobiles in October.

Engineers with both companies are considering adapting other Uniden models.

Americom recently received \$5.5 million of additional venture capital funding for production and marketing of its wide-area dispatch and mobile telephone networking system. The technology applies to mobile fleet dispatch and telephone service.

IBM ventures into mobile data market with Coded contract

Coded Communications, Carlsbad, CA, has landed a contract with International Business Machines (IBM) to supply RF modems, system controllers and associated engineering service for a nationwide mobile data system designed by IBM for a large U.S. customer.

In August at the Associated Public-Safety Communications Officers show in Little Rock, AR, an IBM rep was on hand to investigate the possibilities of the public safety mobile data market.

The company has been exploring the mobile data market for several years, and now it has selected its entry path. IBM is quiet on how much it plans to be a player in the market as a systems integrator.

The initial system is expected to be tested this year, and the customer has operations in many markets, according to a Coded spokesperson. The customer's name and specifics about the actual system and types of terminals to be implemented have not been divulged.

Scala, Kathrein make each other's antennas

Scala Electronic Corporation, Medford, OR, and Kathrein of West Germany have agreed to make each other's antennas. Kathrein land mobile communication antennas will be made by Scala for U.S. customers. Kathrein will make Scala antennas in Germany for the European market.

Scala is expanding operations with the construction of a manufacturing facility in Medford. Completion is expected in midyear.



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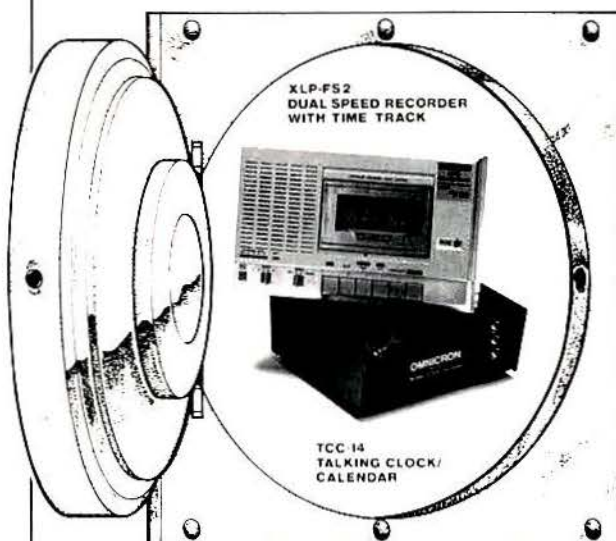


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Test equipment manufacturer enters two-way radio market

Avcom, a company known for its television receive-only (TVRO) receiver and test equipment, has entered the two-way radio market with a portable spectrum analyzer. The analyzer covers 2MHz to 2,000MHz and carries a \$2,675 price.

Design engineer Andy Hatfield founded the company in 1975 and serves as company president. A satellite receiver was the company's first product.

Vice president of operations Pete Gaglio explained what distinguishes the

Avcom spectrum analyzer from others: "Portability and affordability." To achieve "affordability," Gaglio said Avcom designed the instrument for dedicated purposes. For example, the unit's 2MHz to 2,000MHz range is narrower than that of some other instruments, but suits two-way radio applications and reduces the cost.

Avcom makes the unit at its manufacturing and office facility at 500 Southlake Blvd., Richmond, VA 23236; 804-794-2500.

Amateur radio committee proposes no-code license

A committee appointed by the president of the nation's largest association of amateur radio service licensees, the American Radio Relay League, has recommended the creation of a class of

amateur radio license not requiring a knowledge of Morse code. The association's board of directors is set to consider the recommendation during its July 21-22 meeting.

Bird names ad agency

Bird Electronics, Cleveland, has appointed Stevens, Kirkland and Kreer as its public relations and advertising agency. The Chicago-based company handles other land mobile accounts, including Midland LMR, Kansas City, MO; Antenna Specialists, Cleveland; and Glenayre, Vancouver, British Columbia.

Hadron, Electrocom sign licensing pact

Electrocom Automation, Arlington, TX, has signed a two-year, non-exclusive licensing agreement with Hadron, Fairfax, VA, to purchase and resell Hadron's mobile digital telecommunications software. Electrocom will pay an initial licensing fee, and it guarantees to purchase a minimum of 18 MDT software products within two years. Electrocom has the option to purchase Hadron hardware, installation and training services.

The agreement makes it possible for Electrocom to use Hadron's MDT message software to link its Digicom mobile data terminals to dispatchers, host databases and other MDTs for data communications over a radio network.

JaBro acquires Battery Pak

JaBro Batteries, Lisle, IL, has acquired Battery Pak, Spring, TX, for an undisclosed price. The company has been renamed JaBro Batteries S.W. and will retain LeRoy Tietz, former president of Battery Pak, to serve as general manager.

Alliance Telecommunications goes on the selling block

Dallas-based Alliance Telecommunications returns to the selling block after a decision by its majority stockholder, Public Service Company of New Mexico, to sell its non-utility holdings.

Public Service owns more than 75% of Alliance stock through its Meadows Resources subsidiary. Alliance owns Decibel Products, Dallas; BBL Industries, Atlanta; and Alliance Frequency Management, Reston, VA. It also has a 55% interest in Quintron, Quincy, IL.

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News

TPL parent forms division to market AWA products

TPL Communications' parent company, DX Communications, has formed DX Radio Systems division. The new division has exclusive rights to market AWA products throughout the United States and Mexico. AWA, a New Zealand manufacturer, offers side-by-side modular high- and low-power repeaters; base stations; paging transmitters; rural radiotelephone links; and VHF AM aeronautical bases stations and mobiles.

Don Klabunde is president of the new division, which will operate at TPL's headquarters. Klabunde previously was vice president of Tait Electronics, Houston.

DX Radio systems is at 3336 San Fernando Road, Los Angeles, CA 90065; 213-257-0800.

Telular, Antenna Specialists drop infringement suits

Antenna Specialists, Cleveland, has dropped its patent invalidity suit filed against Telular, Wilmette, IL, and subsequently Telular dropped its infringement counter claim. Both companies submitted a dismissal order to the Chicago Federal Court.

Telular president William De Nicolo and Antenna Specialists senior vice president Joseph Shaya negotiated the agreement that led to the dismissal of the companies' lawsuits.

Terms of the agreement have not been released, including whether any payment from one to the other was made, whether the companies have agreed not to pursue future claims in court and whether Antenna Specialists will obtain a license from Telular to use technology protected by Telular's patent.

Commonwealth terminals meet Canadian standards

Commonwealth Communications Industries, Ashland, VA, has received approval from the Canadian Department of Communications for its Mark series of computerized radiopaging terminals. With the approval, Commonwealth is seeking Canadian distribution to market and service the Mark terminals throughout the country.



Technicians take certification exam at International Mobile Communications Expo

The Association of Communications Technicians (ACT) is a membership section of the National Association of Business and Educational Radio (NABER).

March 31, the International Mobile Communications Expo in Las Vegas, NV, offered an opportunity for radio communications technicians to take the NABER technician certification exam. Sixteen candidates took the test.

One said he drove eight hours to Las Vegas for the examination because "my boss said it would be a good idea if I were certified."

Another candidate said "either the FCC license or the certificate is important to have as a measure of technical competence." He said he prefers the NABER certificate because its associated exam is "more up to date" than the FCC exam.

A third candidate found the examination study guide published by NABER to be helpful in preparing for the test.



Taking positions throughout a large room at the Las Vegas Convention Center, candidates for the NABER technician certificate write their examination answers.

"Basic electronics textbooks are helpful, too," he said, because "working on radio equipment becomes second nature after awhile. I stop thinking about the

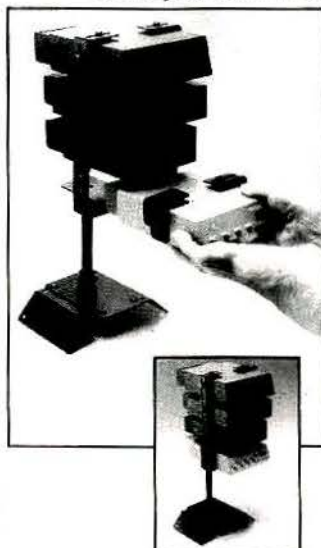
theory behind the work."

ACT has more than 2,000 members, of whom more than 80% have NABER certificates.



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Circle (85) on Fast Fact Card

Frequency coordination report elicits industry comments

An FCC document, "Report to the Commission on Frequency Coordination in the Private Land Mobile Radio Services" discusses the origin of frequency coordination, the development of the current frequency coordination system, benefits and problems associated with frequency coordination, solutions to some of the problems encountered and possible alternatives to the current frequency coordination structure. When it was released late last year, the FCC requested public comment. Comments received at the commission include those from:

- *National Association of Business and Educational Radio*—The use of "representative committees" is mandated by Congress. The requirement limits an expansion of frequency coordinating responsibility.

NABER coordination fees are set by its board, which includes large and small users of private land mobile

equipment who ensure that fees are reasonable.

To protect database accuracy, spectrum efficiency and the commission's spectrum management goals, the association opposes exempting certain applications from frequency coordination.

NABER "does not oppose" the field study option to frequency coordination.

- *Forest Industries Telecommunications*—"The reopening of the whole [frequency coordination] matter is ill advised," FIT's comment reads.

FIT supports "an improved field study application alternative." The organization wants single, representative coordinators to be retained, with no expansion of "exempt" applications. Frequencies offset from channel centers by 12.5kHz should continue to be coordinated, according to FIT, and applicants must indicate to the coordinator the nature of use.

FIT wants better oversight of

interservice sharing regulations, bolstered by a definitive policy to be established by the FCC.

- *Special Industrial Radio Service Association*—"The [FCC document] demonstrates unequivocally that the frequency coordination program now in place is a resounding success.

"Drastic changes in the commission's frequency coordination program are obviously unwarranted.

"A direct access application alternative, should it be deemed necessary by the commission, must be carefully crafted to ensure that it does not adversely affect the fully coordinated private two-way radio environment that has been painstakingly constructed over the past 30 years.

"...Continuation of the requirement that coordinators must be representative of their users, coupled with stronger and better-directed commission oversight of the coordinators' performance, should



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ensure that the existing coordinating process will continue to serve the public interest for many years to come."

• **Manufacturers Radio Frequency Advisory Committee**—"The frequency coordination program has been a clear success." The committee cites a "99%-plus consumer satisfaction" rate,

based on approximately 300 to 500 general complaints the FCC has received during a two-year period in which more than 50,000 private land mobile radio frequency coordinations were performed.

• **Nynex Telephone Companies**—As a two-way radio user with licenses issued

in the telephone maintenance radio service, Nynex stated that coordination fees "are commensurate with the services."



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June 1989 Mobile Radio Technology 77

Readers' choice

Of all the new products and services covered in the October issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact number on the Fast Fact Card found in the back and mail the card to us.

Waterproof case fits VHF portables

The Watersound VHF transparent case from EWA-Marine protects VHF hand-helds from saltwater spray without disrupting radio operation through the housing. The standard size fits marine VHF radios, and a larger size fits land-based VHF units.

Circle (516) on Fast Fact Card

Computer modem transmits data via two-way radio

The TEM-Link modem allows computers to receive and transmit data over RF. Made by Tauber Electronics, the modem works with any radio operating on UHF public access frequencies. The modem plugs into existing computer chassis or a separate enclosure can be provided. The company will determine a user's radio type, baud rate, data connections, operation mode, power source and



packaging requirement. Phone hookups and other peripherals are not needed with the modem.

Circle (515) on Fast Fact Card

Radio design program calculates coverage, paths

The Pathfinder Plus radio system design software from The Jack Daniel Company allows the user to see what effect the change of a single characteristic in a radio system design would have, without entering additional information. The program calculates coverage, signal margins, tower height requirements, power levels, path gains and losses, and

distance. Information automatically is converted and displayed in decibels referenced to a milliwatt (dBm) and microvolts or watts, regardless of which type of data entry is made by the user. The software is available as a 5¼-inch disk for PC, XT and AT monochrome or color-compatible computers.

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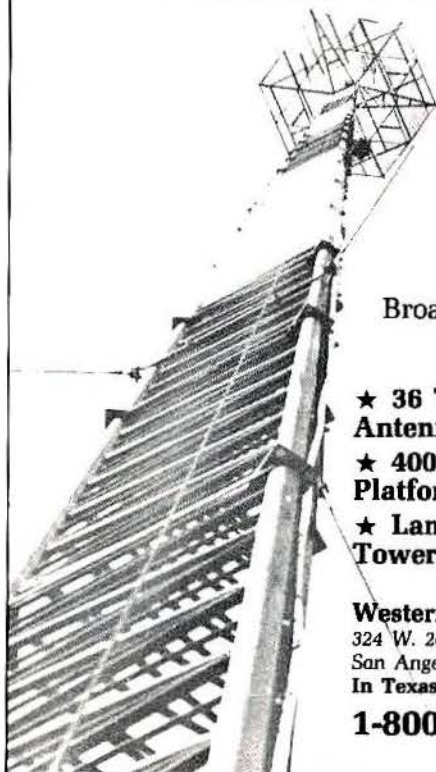
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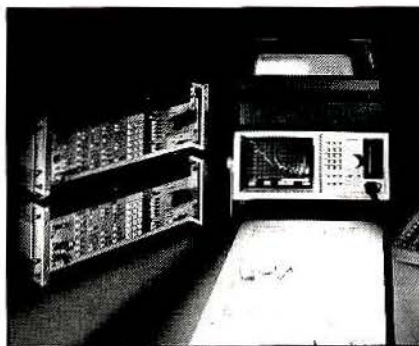
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Test software enables RFI measure to FCC specs

The EMI test software EZM-K1 from **Rohde & Schwarz** works with the company's test receivers ESH 3 and ESVP and with its spectrum monitor EZM for EMI measurements. RFI voltages, currents, powers and field strengths can be measured to FCC regulations. The software produces the results on a printer or plotter. The software splits tests in two stages: a preliminary measurement on the interference spectrum and a final measurement at critical frequencies. Test setup can be automatic or flexible.



Circle (224) on Fast Fact Card

Pulse-heat soldering iron delivers controlled temperature

The SMR 25 pulse-heat reflow system from **Pace** provides controlled temperature ramp-up from room temperature. The soldering iron tips of the SMR 25 grasp the component leads cold and heat up rapidly. Non-soldering tips can grasp the component and hold down the leads before and during reflow

and cool down. The unit comes with three rapid connect and disconnect handpieces, an assortment of compact tips, a handpiece holder, hot cubby, universal power cord and foot-pedal switch. Optional tips are available.

Circle (434) on Fast Fact Card

Radio coupling device suits cellular uses



The Celjack telephone to cellular radio coupling device from **Telular** features precision dial tone; female RJ11C connector; distinct tones for receiver off hook; lock; roam; pulse or tone dialing; and loop or ground start.

Circle (303) on Fast Fact Card

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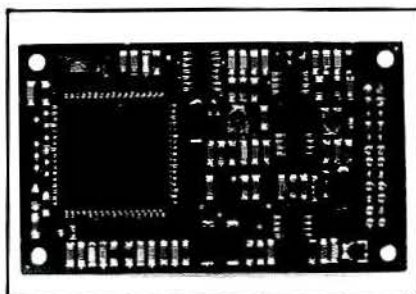
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Circle (94) on Fast Fact Card

New products

High-speed radio modem operates from 5Vdc to 14Vdc

Model HSM-5 high-speed radio modem from **GLB Electronics** features low-current drain and 9,600 baud or 4,800 baud data rates. The OEM subassembly interfaces a digital data source and an FM radio receiver for data transfer. It works with phase-modulated and synthesized radios and operates from 5Vdc to 14Vdc. Features include a transmission timer and a power-down mode.



Circle (436) on Fast Fact Card

Time domain reflectometer displays 3 readings at once

The Riser-Bond 1210 time domain reflectometer from **Tessco** measures cable lengths, conditions and faults without extra accessories. The cable fault locator displays waveform, auto-distance calculation and fault severity simultaneously. A thermal data logging printer and rechargeable nicad batteries are standard.

Circle (304) on Fast Fact Card

Portable spectrum analyzer covers 2MHz to 1,000MHz

Model PSA-65A portable spectrum analyzer spans 2MHz to 1,000MHz in one sweep with a sensitivity greater than -90dBm in narrow spans. The **Avcom** unit weighs 18 pounds and is battery- or line-operated. Options available include frequency extenders, audio demod, log periodic antennas and carrying case.

Circle (435) on Fast Fact Card

Repeater panel upgraded

The CSI-32 community tone repeater panel from **CSI** features design improvements such as battery-backed random access memory (RAM), DTMF decode chip for remote control and time hit keystroke. Other upgrades are improved COS circuitry and remote programming transponder for programming verification.

Circle (318) on Fast Fact Card

Replacement scope probes

Two series of replacement oscilloscope probe kits from **Pomona Electronics** mate with B&K, Tektronix, Hewlett-Packard, Philips and Leader scopes. A low-cost standard version is available, and a modular replacement series fitted with threaded connections is offered.

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Report shows 6% increase in cellular salaries

In the telecommunications hiring field, layoffs and hiring freezes are common as mergers and consolidations continue, according to a recent survey. The "Twentieth Annual Telecommunications Salary Report" by **Personal Resources International** shows, however, the cellular radio industry's

continuing climb with cellular salaries increasing an average of 6%. Individuals with start-of-the-art paging, trunking and interface cellular systems experience are in demand in major metropolitan areas and in medium-sized cities, the report reads.

Circle (500) on Fast Fact Card

NAM programming guide for cellular is available

A programming guide for cellular programmable NAMs is available from **Curtis Electro Devices**. The guide lists programming steps for nearly 40 model

lines, some of which have multiple models. The hard-bound looseleaf book is called **Curtis NAMfax**.

Circle (505) on Fast Fact Card

Industry group offers two mobile standards

Two standards for land mobile communications are available from the **Electronic Industries Association**. EIA-152-C addresses minimum standards for land mobile communication

FM or PM transmitters. EIA-220-B lists minimum standards for land mobile continuous-tone controlled squelch (CTCSS) systems.

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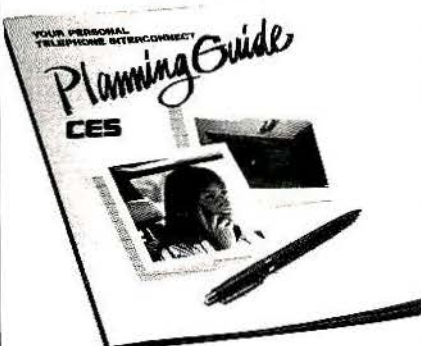
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Forest Service land use fees are 'unreasonable'

Fees the Forest Service plans to assess for land used by land mobile radio services are too high, according to respondents to the November "What Do You Think?" questionnaire. Of those involved with Forest Service land contracts, 75% consider the fees high. No respondents reported the fees as too low,

and 25% said the fees were average or in line with other land-use assessments.

In its charges for land use for communications equipment, the Forest Service is not fair to all parties, most of the respondents report. "Fees are based on the commercial value of service provided and comparable to state

land management charges," notes a communications specialist.

"Rates for two-way radio dealers, RCCs, etc. are high in comparison to other types of users," adds a two-way dealer. According to documentation from the Idaho bureau of land management that was attached to a survey: "Rather than by appraisal, values were determined by statistical analysis. The value ranges are distorted on the high side, especially TV, radio and commercial two-way communications."

"Companies that use Forest Service land for internal communications purposes should pay less than those that have their service for profit," comments a telecom engineer. "I will pay more in fees than a TV station. I wish my company grossed as much as a TV station," echoes a two-way dealer.

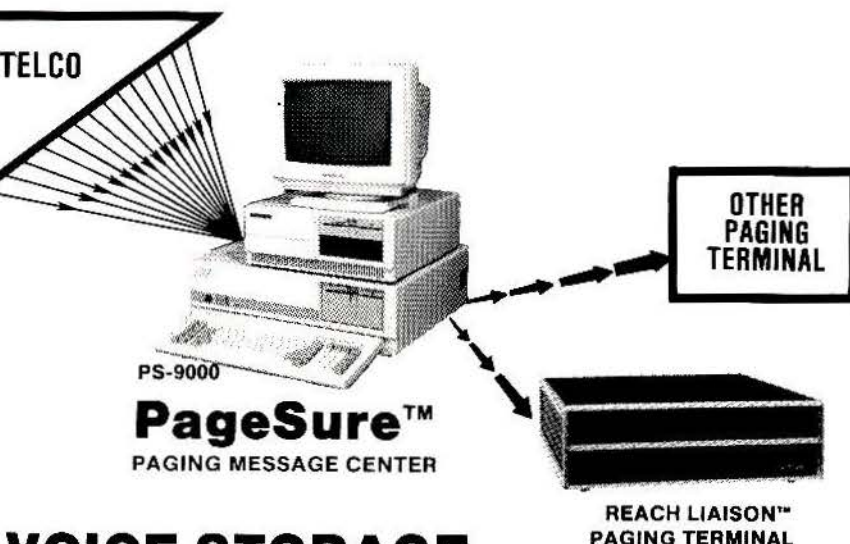
Respondents report that charges vary from site. "Charges vary in different regions and vary according to whether it is a microwave or base station," contends a respondent. "They attempt to dictate local fees from the data gathered in other areas; it's impossible to have any sort of dialogue with the people making the decisions," adds a dealer.

"If they want to participate in the profit, they should also participate in the risks and expenses," laments a common carrier engineer. "I already paid for the USFS building and equipment once through taxes," comments an owner of a repair facility.

The fees are "10 times the cost of private sites," discloses a two-way dealer. The fees "would drive up rental prices by as much as 300% in some areas," agrees a site general manager.

Most of the respondents concur that the increased fee proposal will force them to relocate their radio communications. "We plan on moving to a new private site that we can afford," notes a dealer. "I may have to move," adds an owner of a repair shop.

Other implications of the proposed fees include: "If fees go like proposed, I most likely won't expand my SMR system." "We will lose customers and profit with the proposed increases."



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Changes at Mobile Communications Corporation of America, Jackson, MS: **Gary J. Gouin**, general manager of the company's Chicago office, advances to regional manager of MobileComm's newly created midwest region, based in Chicago. **Dan Collins**, general manager of the Cleveland and Akron offices, advances to general manager of MobileComm's Chicago office. **Larry Brunell**, general manager of the Jackson office, advances to general manager of MobileComm's Cleveland and Akron offices.

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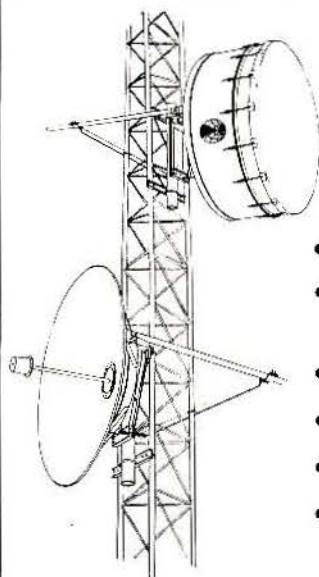
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Calendar

June

3—Radio Club of America lunch, in conjunction with the American Radio Relay League meeting, Sheraton CentrePark, Arlington, TX. Contact Ray Trott: 214-580-1911.

18-21—Utilities Telecommunications Council Annual Meeting, Lake Buena Vista Palace, Orlando, FL. Contact: 301-621-5596.

21-23—Associated Public-Safety Communications Officers Northwest Training Conference and Trade Show, West Coast Wenatchee Center Hotel and Convention Center, Wenatchee, WA. Contact: Pam Ratcliffe, 206-774-3583.

22-23—American SMR Network Association Annual Meeting, The Capital Hilton, Washington, DC. Contact: 202-331-7773.

July

17-19—Forestry-Conservation Communications Association, Coeur D'Alene, ID. Contact: 208-765-1811.

August

6-10—Associated Public-Safety Communications Officers 55th Annual National Conference, John Ascuaga's Nugget, Sparks, NV. Contact: 800-824-1850.

27-30—International Association of Fire Chiefs Annual Meeting, Indianapolis Convention Center, Indianapolis. Contact: 202-833-3420.

September

7-9—Land Mobile Expo/East, Orange County Convention Center/Civic Center, Orlando, FL. Contact: 303-220-0600.

28-30—Special Industrial Radio Service Association Annual Meeting, Lake Tahoe Hyatt, Lake Tahoe, NV. Contact: 703-528-5115.

October

4-7—Telocator 41st Annual Convention and Exposition, Washington Convention Center, Washington, DC. Contact: 202-467-4781.

14-19—International Association of Chiefs of Police Annual Meeting, Commonwealth Convention Center, Louisville, KY. Contact: 301-948-0922.

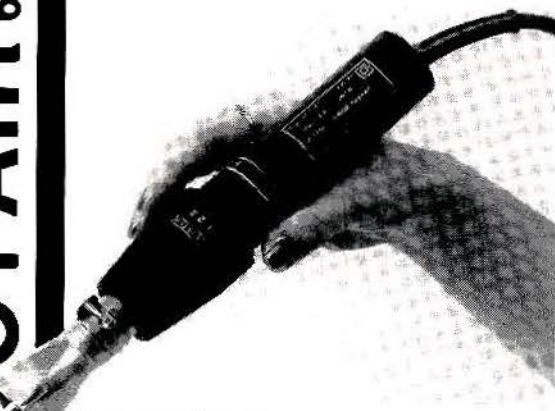
16-17—American SMR Network Association Fall Meeting, Ritz Carlton Hotel, Rancho Mirage, CA. Contact: 202-331-7773.



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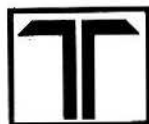
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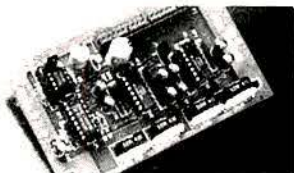
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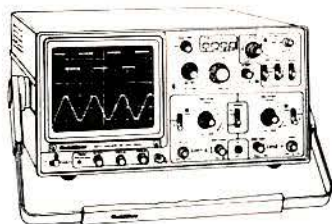
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Technicians may observe good hybrid balance at a single test frequency, but not over a wide frequency range.

WHY THEY FAIL

For a hybrid to exhibit balance over a wide range of frequencies, its network must accurately model telephone line impedance.

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While using a standard FM service monitor, observe an in-progress, duplex telephone call. If the repeated transmitter deviation by a distant mobile unit is **EQUAL** to or **GREATER** than that from the telephone caller, the system has insufficient hybrid balance. **UPGRADE TODAY WITH BN-100 NETWORKS.**

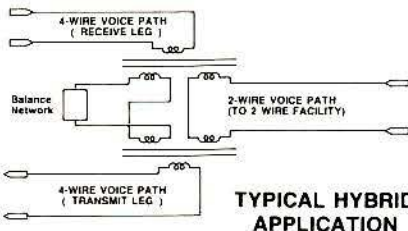
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The new BN-100 Precision Balance Network provides **WIDE RANGE** hybrid balance for either long or short telephone drops.

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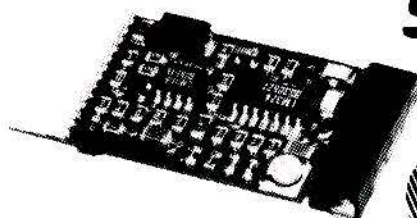
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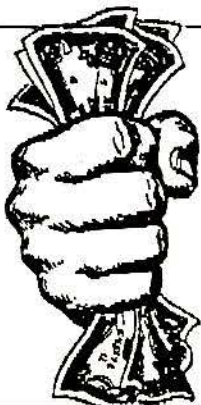
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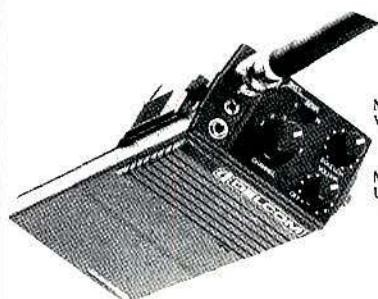
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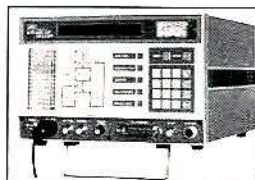
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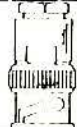
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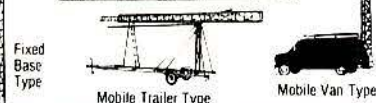
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Company	Page Number	Fast Fact Number	Advertiser Hotline	Company	Page Number	Fast Fact Number	Advertiser Hotline
AAA Communication Mfg.	91	119	800/283-5158	IFR System, Inc.	23	22	316/522-4981
Advanced Electronic Applications, Inc.	46	45	206/775-7373	JaBRO Batteries, Inc.	76	87	312/964-9358
Advanced Receiver Research	20	19	203/582-9409	JFW Industries	22	21	317/887-1340
AIE Corporation	74	83	803/532-9256	Kenwood U.S.A. Corporation	47	46	213/639-4200
Alexander Batteries	26	25	515/423-8955	Larsen Electronics, Inc.	21	20	206/573-2722
America West C&E	70	75	307/382-5663	Marconi Instruments	13	11	800/233-2955
Antenna Specialists Co.	IFC	1	216/349-8400	Maxon	65	65	816/891-6320
Auburn Electronics Labs	94	124	502/542-6000	Maxrad, Inc.	52	51	312/595-3933
B-D Crystal	89	114	306/283-5000	Micro-Quick Systems, Inc.	79,95	93,125	714/980-1034
Band-It-Idex	64	64	303/320-4555	Midian Electronics, Inc.	24	23	602/884-7981
Barnett Electronics	88		800/423-3858	Milcom International, Inc.	25	24	714/554-1710
BEE Electronics, Inc.	34	33	800/336-3115	Mobile Mark, Inc.	62	62	312/671-6690
Bendix/King	35	35	913/842-0402	Modublox & Co., Inc.	83	99	619/456-0016
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C.T. Systems	41	40	800/245-6356	NCE/National Custom Enterprises, Inc.	67	69	612/890-1360
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Cellular Depot Inc.	87	110	215/364-7890	ORA Electronics	37	37	818/701-5848
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Commonwealth Comms Industries Ltd	63	63	800/633-8844	Radiation Systems, Inc.	84	101	312/298-9420
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Connect Systems	17	16	213/373-6803	Royal Insurance	57	57	
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Data Signal, Inc.	42	41	912/883-4703	Shinwa Communications of America	38	38	405/232-7272
Decibel Products, Inc.	45	44	214/631-0310	Sigtone Inc.	36	36	213/463-4474
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